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Energy Output Registers Increase in First 4 Months of 1990

40100052A Beijing CHINA DAILY in English 9 May 90 p 2

[Article by staff reporter Huang Xiang: "Energy Industry Powers Ahead"]

[Text] China's energy industry registered an overall increase in the first four months this year, according to the Ministry of Energy Resources.

Coal output reached 319.6 million tons during that time, an increase of 7.21 per cent over the same period last year.

The figure represented 30.15 per cent of the year's target.

A ministry official said State-run mines turned out 160.2 million tons of coal, 35.41 per cent of the year's target and an increase of 5.96 per cent over that of 1989 when the country produced a record 1.04 billion tons.

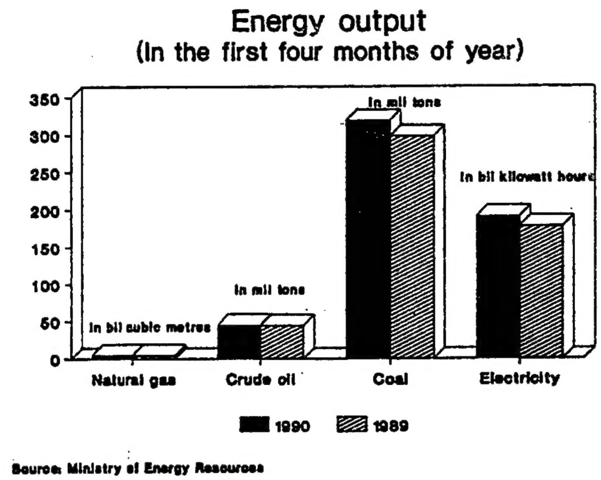
The industry was told to produce 1.06 billion tons of coal this year, of which State-run mines should contribute at least 452.5 million tons and hopefully 500 million.

According to the official, the power industry generated 191.7 billion kilowatt hours of electricity during the first four months.

This was a 7.66 per cent increase over the same period last year. The industry produced 582 billion kilowatt hours of electricity in total last year.

Thermal power plants produced 160.3 billion kilowatt hours of electricity in the first four months of this year, an increase of 6.88 per cent, while hydroelectricity production amounted to 31.4 billion kilowatt hours, an increase of 7.48 per cent.

Crude oil output saw an increase of 1.01 per cent to 45.12 million tons by the end of April, 540,000 tons more than the figure for the same period last year.



Largest Power Facilities Listed

90P60012 Beijing RENMIN RIBAO in Chinese 18 Mar 90 p 8

[Text] 1. The largest hydropower station is Gezhouba: 2.715 million kilowatts installed capacity

2. The largest thermal power plant is Jianbi: 1.625 million kilowatts installed capacity

3. The largest nuclear power plant is Dayawan (under construction): 1.8 million kilowatts installed capacity

4. The largest pumped-storage power station is Guangzhou: 1.2 million kilowatts installed capacity

5. The largest tidal power station is Jiangxia: 3,900 kilowatts installed capacity

6. The largest wind power station is Caiwobao: 4,000 kilowatts installed capacity

7. The largest geothermal power plant is Yangbajing: 13,000 kilowatts installed capacity

State Stresses Power Generator Production

40100056A Beijing CHINA DAILY (Economics and Business) in English 25 May 90 p 2

[Article by staff reporter Ren Kan]

[Text] The Ministry of Machine-Building and Electronics Industry is concentrating on the production of large power generators with imported advanced technology for the country's key power stations.

Before 1994, the ministry will produce two 600,000-kilowatt and seven 300,000-kilowatt thermal power generators for large power stations in Hubei, Heilongjiang, Anhui and Guangdong provinces, said Wu Xiaohua, an official with the ministry.

He said that these two kinds of large power generators will be produced with advanced American technology.

In 1980, China signed technology-transferring contracts with two American companies. According to the 15-term contracts, the companies will provide latest technical files about these kinds of generators.

Wu said that the production of these generators will give firm support to China's ambition of greatly increasing the electricity-generating capacity during this decade.

By the end of this century, the country is planning to increase its electricity to 1.2 trillion kilowatt hours a year, compared with last year's 582 billion.

Wu said one of the two 600,000-kilowatt generators, the largest of its kind in China, will be made this year for the Pingwei Power Station in Anhui Province.

By 1993, the other 600,000-kilowatt generator will be made for the expansion project of a power plant in Harbin, capital of Heilongjiang Province.

The project aims to provide enough power to industries in the region including Daqing, China's largest oil producer.

Wu said his ministry this year will also complete the production of a 300,000-kilowatt thermal power generator for a large power plant in Hubei Province.

By 1992, Wu said, the ministry will produce another two 300,000-kilowatt power generators for Wujing Power Station in Shanghai, which aimed at ensuring the supply of electricity for a large petrochemical factory nearby.

Another four generators of this kind will be produced for two power stations in Hubei Province and Shenzhen Special Economic Zone.

Wu said the ministry is also preparing to provide four 200,000-kilowatt pump turbines for Shisanling Hydropower Plant in Beijing. This plant is planning to use loans from a Japanese bank.

Wu said the ministry will also concentrate on the development of equipment for ultra-high voltage transmission project.

These equipment include switch, surge arrester and relay protection equipment.

During the past years, the ministry has spent millions of US dollars importing production technology from the United States, France, Canada and West Germany.

The transmission equipment produced with imported technology has been put into operation in the Gezhouba sub-station in Hubei Province.

Wu said his ministry this year will provide equipment for a 500 kilovolt sub-station project in Hebei Province.

The sub-station is to serve a nearby power plant. The plant will put one of its two 300,000-kilowatt thermal power generators into operation this year to ensure electricity for the Asiad.

Hydropower Still Central to Sichuan's Energy Development Plans

906B0055B Beijing LIAOWANG [OUTLOOK] in Chinese No 12, 19 Mar 90 pp 15-16

[Article by Li Dachuan [2621 1129 1557]: "Sichuan Province Decides on a New Strategy To Develop Hydropower Resources"]

[Text] China's Sichuan Province recently decided on the focus of energy resource development and construction up to the end of the 20th century and into the early part of the 21st century: all forces in Sichuan should focus on trying to obtain more domestic and foreign capital and technology to develop Jinsha Jiang, Yalong Jiang, and Dadu He (the "three rivers") to alleviate Sichuan's electric power shortage.

I. Energy Resource Shortages, Serious Power Shortages

To learn about Sichuan Province's strategy for developing hydropower resources, I visited Zou Guangyan [6760 1639 0917], deputy director of the Sichuan Provincial Planning and Economics Commission. He explained the causes and effects of developing "three rivers" hydropower resources.

Sichuan's long-term comprehensive and extensive energy shortage seriously restricts development of the national economy. Sichuan Province now has an installed generating capacity of 6,050 MW. Its per capita power consumption is only about one-half the national per capita average and many rural areas have no electricity. The yearly power shortage is 7 billion kWh and the operation rate of electrically powered equipment in Sichuan is less than 70 percent. It has the largest power shortage among China's provinces. Moreover, Sichuan has annual coal shortages of 2.5 million tons and natural gas shortages of 600 million cubic meters. It relies almost entirely on other provinces for purchases of finished oil products.

Sichuan has limited coal resources, with proven reserves of less than 10 billion tons, 1 percent of the total in China, and over 3.6 billion tons has now been mined. Minable industrial reserves are just 500 million tons. Estimates by Sichuan Province's coal departments indicate that Sichuan's coal output levels can only be sustained at about 650 million tons.

Sichuan Province has very few petroleum reserves and available natural gas reserves of 120 billion cubic meters, only sufficient for 13 years of exploitation.

II. Bring Prosperity, Develop Hydropower

Sichuan Province's advantage is an abundance of hydropower resources. Sichuan has over 1,300 large and small rivers with theoretical hydropower resource reserves of 150,000 MW. It has a developable installed generating capacity of more than 91,000 MW which could produce an average of 500 billion-plus kWh each year, equal to 24.2 percent and 26.8 percent, respectively, of the totals for China and 46 percent and 50 percent of the totals for the Chang Jiang Basin, putting it in first place among China's provinces and autonomous regions, but the degree of development at present is very low. Statistics show that Sichuan Province had an installed hydropower generating capacity of only 3,060 MW at the end of 1988 which generated 13.1 billion kWh annually, just 3.3 percent of its developable capacity (the figure for China as a whole is 8 percent) and just 2.5 percent of developable yearly power output (the figure for China as a whole is 5.7 percent), so it is less than one-half the national degree of development in both areas. The extent of development in China is far lower than northern European nations which have a high degree of development and far lower than developing nations like India, Brazil, and others.

By substituting hydropower for coal-fired and oil-fired power, calculating at about 1 jin of coal per kWh, the 78 percent of Sichuan Province's developable hydropower resources concentrated in the basins of the "three rivers" could generate a total of 400 billion kWh of power annually, which would save over 400 million tons of coal, the equivalent of 40 percent of yearly coal output in China at the present time and the total increase in coal output planned for the next 10 years.

A solution to Sichuan's energy problems must begin with structural conditions of Sichuan's resource resources, take full advantage of its hydropower resources, make major efforts to develop hydropower, and continually increase hydropower as a proportion of the energy resource production structure. Moreover, the conditions exist to make Sichuan China's biggest hydropower resource base area.

Sichuan Province is now making two strategic shifts in developing the electric power industry. One is combined development of hydropower and thermal power and shifting to a predominance of hydropower and transferring its strategic focus to development of hydropower resources. The second shift is a gradual shift from scattered local efforts to develop small-scale hydropower to making large-scale stations the backbone and medium and small-scale stations the foundation in developing more medium-scale commercial hydropower stations.

Zou Guangyan feels conditions already exist in Sichuan Province to accomplish these two strategic shifts. He reviewed the hydropower resource development situation in China since the nation was founded. In 1949, the installed hydropower generating capacity in Sichuan was just 47 MW and yearly power output was only 16 million kWh. After 40 years of construction, the installed generating capacity in Sichuan Province has now grown to 3,060 MW, equal to 50.4 percent of the total installed generating capacity in Sichuan. Hydropower generates 13.1 billion kWh, which is 44.1 percent of total power output in Sichuan, a 600-fold increase over the figure shortly after new China was founded.

He said that by the end of this century, Sichuan Province plans to have a total installed generating capacity of 18,000 MW, with hydropower accounting for 12,000 MW. Total power output will reach 80 billion kWh, with hydropower accounting for 44 billion kWh. The extent of hydropower development will increase from the present 3.3 percent to 13.1 percent, but this degree of development will still be very low.

III. Development of the "Three Rivers" Is Certainly Feasible

Deputy Director Zou feels that many favorable conditions now exist for developing the "three rivers." First, the state has made energy resources and communications the focus of its development strategy, and hydropower is the focus in south China. The state has decided on 12 large-scale hydropower base areas, and one-fourth are located on the "three rivers." State policies have already given us substantial support. Moreover, the Sichuan Provincial CPC Committee and Provincial Government have focused on developing electric power as a key, leading industry. The Provincial CPC Committee and Government have also expended great effort in focusing on energy resources over the past few years and they have made energy and communications the most basic industries and focus in Sichuan Province.

Second, we already have a definite foundation and we have begun one or two power stations on the "three rivers" which can be called starting power stations. For example, China's biggest hydropower station, Ertan Power Station with an installed generating capacity of 3,300 MW, is now under construction on Yalong Jiang. On Dadu He, the 700 MW Longzui low dam power station has been completed and 600 MW Tongjiezi Power Station is now under construction.

Third, hydropower construction has already begun in Sichuan Province and we have three solid foundations. Sichuan Province now has almost 1,600 small hydropower stations and sizable construction staffs and management personnel staffs trained while building these hydropower stations, so we are not worried about having technical personnel to build more power stations.

IV. Rolling Development, Gratifying Prospects

The development principle for all of Sichuan Province's hydropower resources is making large power stations the backbone and integrating large, medium-sized, and small power stations. The principle for river systems of the Chang Jiang is to proceed first in the upper reaches and later in the lower reaches, to develop the tributaries first and the trunk later, and to work on easy projects first and hard ones later to implement rolling river basin development, establish a series of hydropower base areas, and achieve a magnificent strategy of "transmitting power from west to east China" and transmit power out of Sichuan.

Zou Guangyan said that Sichuan Province should make accelerated development of "three rivers" hydropower resources the turning point and Ertan Hydropower Station the focus to convert them quickly from preparatory projects during the Seventh 5-Year Plan into formal construction startup projects and strive to place all of them into operation before the year 2000. In addition, we should begin now to focus on preparatory work for Baobugou on Dadu He, Jinping on Yalong Jiang, Xiluo Du on Jinsha Jiang, and several other key projects. We should strive to make Baobugou Hydropower Station the successor engineering project to Ertan Power Station, make the Jinping first and second cascade hydropower stations the successor engineering projects to Baobugou, and make Xiangjiaba Hydropower Station on Xiluo Du and Tongyi Jiang key hydropower power source engineering projects to "transmit power from west to east China" by transmitting power out of Sichuan for the state. We should also combine a focus on the pace of project construction at Tongjiezi, Baozhusi, and other projects now under construction with a focus on building several medium-sized hydropower stations and strive to include several relatively mature medium-scale hydropower stations like Taipingyi, Dongxiguan, Yele, Tongtou, Yucheng, Caoyushui, Zipingpu, and others among state projects to push for construction in the near term. Moreover, Tongzilin Hydropower Station should be built in synchronization with Ertan and Zilanba Hydropower Station should be built in synchronization with Baozhusi to give them a counter-regulation role and increase the overall results of continuous cascade development.

To accomplish this, Sichuan will establish a new development system, implement multi-channel and multi-level power development, and establish different types of hydropower development companies. In addition, with a prerequisite of support from the state and all areas for the initial stages, they will take responsibility for raising capital to prepare for construction, assume responsibility for construction and management and their own rolling cascade development tasks to turn construction on the "three rivers" into a large-scale hydropower base area for China's "transmitting power from west to east China" by transmitting power out of Sichuan.

V. Welcome Investments, Share the Benefits

Deputy Director Zou Guangyan told me that Sichuan will offer preferential policies and measures in warmly welcoming Chinese and foreign investors to come to Sichuan for cooperating in developing Jinsha Jiang, Yalong Jiang, and Dadu He hydropower resources.

He said that for both Chinese and foreign investors, those who invest in the "three rivers" hydropower resource "motherlode" region will derive sufficient benefits. He guarantees investors that a minimum investment here will obtain the maximum benefits from developing hydropower. For this reason, Sichuan Province will adopt an arrangement for joint administration and compensated trade. One

form will use the area's abundant mineral products, silkworm cocoons, and so on for comprehensive compensation. Another form would use a combination of electricity and minerals for compensation such as development and processing of iron alloys, aluminum alloys, products made using electricity, and so on.

Zou Guangyan said that for Chinese investors, the period for repayment of the principal would not exceed 10 years starting with power generation by the first generator. During the period of cooperation, risks and benefits of the power station would be shared and the interests of the investors would be fully guaranteed.

Investors Eye Huge Power Plant in Inner Mongolia

40100053A Beijing CHINA DAILY (Economics and Business) in English 18 May 90 p 2

[Article by staff reporter Huang Xiang]

[Text] Plans to build a thermal power plant in Inner Mongolia Autonomous Region—a power plant which would be China's largest—are under consideration by potential investors, CHINA DAILY has learned.

The proposed coal-fired plant is in Gudalate. Total capacity will be 5 million kilowatts.

Currently Ertan Hydropower Station in Sichuan Province, which is still under construction, is the country's biggest power plant with a generating capacity of 3.3 million kilowatts.

The top coal-fired plant at present is the 1.625-million-kilowatt Jianbi Power Plant in Jiangsu Province, which went into operation in 1987.

Investment in the Gudalate plant will be shared by local government and the State Energy Investment Corporation, the principal State investor.

A first-phase construction with a capacity of 1.2 million kilowatts would be completed before 1995.

Experts from the Corporation said Gudalate is an ideal site for such a major power undertaking.

It is close to the edge of a Shenfu-Dongsheng Coal Field in neighbouring Shaanxi Province.

With 12 separate mines, the coal field has a production capacity of 8.1 million tons. One of them, with an annual capacity of 600,000 tons, has already gone into operation.

Experts estimate coal deposits in Shenfu-Dongsheng at more than 230 billion tons in an area of 10,000 square miles, most of which are of high quality coal.

Xiaolongtan No 3 Generator Operational

906B0055A Kunming YUNNAN RIBAO in Chinese 23 Dec 89 p 1

[Article: "No 3 Generator at Xiaolongtan Power Plant Connects to Grid, Generates Power Ahead of Schedule"]

[Text] At a time when Yunnan Province is facing a serious power shortage, the 100 MW installed generating capacity No 3 generator at Xiaolongtan Power Plant was connected to the grid and began generating power at 0351 hours in the early morning of 21 December 1989, 3 months ahead of the original plan.

Since groundbreaking in 1983 to begin construction of Xiaolongtan Power Plant, the No 1 and No 2 generators have begun operating and producing power. Yunnan's power shortage in 1989 became the motive source and pressure for the builders of Xiaolongtan Power Plant. They overcame all types of difficulties to speed up construction and complete civil engineering tasks for the No 3 generator ahead of schedule, and they decided to place the No 3 generator, which the original plan called for producing power in the spring of 1990, into operation 3 months ahead of schedule to begin generating power. To accomplish this, employees in the Yunnan Provincial Power Bureau's Thermal Power Construction Company went all-out in going to the site to work on installing the generator and reduced the installation time from the normal 240-plus days to 180 days, enabling formal ignition of the No 3 generator on 1 December 1989, and they began 72 hours of trial operation on the evening of 20 December 1989.

Installation of the No 3 generator at Xiaolongtan Power Plant received support and concern from the Yunnan Provincial CPC Committee, Provincial Government, and all departments. Relevant truck teams in the Yunnan Provincial Communications Department took the initiative in transporting the huge components and created conditions to complete generator installation ahead of schedule.

Startup of the No 3 generator at Xiaolongtan Power Plant has alleviated the electric power shortage in Yunnan Province. The builders are now struggling to make the No 4 generator operational.

1990 Target for Big Government Mines Set at 500 Million Tons

40100052B Beijing CHINA DAILY in English 7 May 90 p 3

[Article by Huang Xiang: "Mines Dig Deep for New Goal"]

[Text] The government's target for the 620 major coal mines this year is set at 500 million tons, says Minister of Energy Huang Yicheng.

The figure is 23 million tons higher than for 1989, Huang said at a national coal conference recently.

Major State-run mines in China are either run by the China National Coal Corporation or by the Northeast & Inner Mongolia Coal Industry Corporation.

Together they turned out 470 million tons of the landmark 1.04 billion tons of coal produced in China last year.

"The target is actually a must. And we should produce more under the current favourable policy," he said.

Huang was referring to the government's increased capital investment and subsidy this year for the industry.

The State Council earmarked 7.7 billion yuan ($1.64 billion) in capital investment in the coal industry, 1 billion yuan ($213 million) more than the previous year. The electric power industry got a smaller share this year.

"This is a clear indication that the central government attaches great importance to this industry," Huang said.

In the past few years coal and agriculture have become the country's only two industries seeing a steady increase in public investment.

Huang said he expects more government investment in the year ahead.

In addition to increased investment, the State Council will increase subsidies to the industry to compensate for increasing deficits suffered by most State-run mines due to the low fixed price for coal.

The price of that portion of coal produced by the two state corporations is subject to strict government control, 40 yuan ($8.50) per ton. So most of the mines, with increased workforces to keep production growing, have been losing money in recent years.

Experts noted the situation stands in sharp contrast to most of the locally-run mines, whose products sell at free market prices, usually two to five times higher than the fixed State price.

In recent years the State Council has backed the industry with subsidies as well as with preferential policies. Last year the subsidy amounted to 2.4 billion yuan ($510 million), a billion yuan ($213 million) more than in 1988.

The minister also pointed out a few major disadvantages which he said are affecting production and construction.

He said the double-digit inflation of the past five years has eaten up 10 billion yuan ($2.13 billion) marked for capital construction.

This would mean a loss of several million tons in production capacity in that half decade.

According to the Seventh Five-Year Plan (1986-90) the industry should receive 31.5 billion yuan ($6.7 billion) in capital construction.

Huang also said the equipment in State-run mines is worn out.

A report on the China National Coal Corporation said half of its mining equipment had to undergo extensive repairs to prevent breakdowns.

It said 201 of its extractor machines and 420 of its tunnelling machines needed to be replaced. The corporation currently uses 1,300 pieces of such equipment which turned out 224 million tons of coal in 1989.

The corporation cannot afford to replace all these expensive machines at one time, he said.

One extractor costs 15 million yuan ($3.2 million) and is capable of producing 1 million tons of coal every year.

Huang said experts will soon organize major overhauls of these machines and are expected to make specific suggestions on their management.

Earlier, experts had suggested the State Council spend 4.7 billion yuan ($1 billion) to replace these machines.

Coal Export Goal Up by 700,000 Tons

40100056B Beijing CHINA DAILY (Economics and Business) in English 26 May 90 p 2

[Article by staff reporter Huang Xiang]

[Text] China plans to sell 16 million tons of coal in 1990—700,000 tons more than during 1989, CHINA DAILY has learned.

The target is a 4.6 percent rise over 1989 when the country earned $551 million from its coal exports.

"We have every reason to meet the State target for the year," said Huang Shaochen, deputy general manager of China National Coal Import and Export Corporation, at the conclusion of the annual coal export conference yesterday.

The corporation became the country's sole representative in 1989 for coal trade.

Huang said conditions are now ripe to expand coal exports, one of China's important sources of foreign currency.

He expects his corporation to lose no time cashing in on the favourable conditions at present—namely, a better economic order, devalued Renminbi, less domestic demand, increased production, and a more stable market overseas.

Coal exports amounted to 4.91 million tons in the first four months of 1990, 1.16 percent over the same period last year.

In the past, China's coal exports were frequently hampered by growing domestic power shortage, which was made worse by a chaotic coal market.

Industrial growth, which currently eats up 70 percent of coal output every year, has been slowed down compared with that of two years ago due to the nationwide austerity drive, a situation which energy experts say has greatly relieved the power strain all over the country.

In addition, the government is gradually tightening control over the coal market. Measures include a screening of the coal allocation and transportation systems, and the imposition of a ceiling coal price.

Huang said all these measures will help considerably for a steady export growth.

He noted that domestic production continues to climb along with the overseas market price.

In the past four months, the industry produced 319.6 million tons of coal, an increase of 7.2 percent over the same period last year. China turned out a landmark 1.04 billion tons of coal in 1989.

However, he admitted that coal exports are now seriously troubled by the declining quality of coal.

He said overseas clients keep complaining about too much water and ash content and "other impurities" in bituminous, anthracite and coking coal.

Most of the country's coal exports are to Hong Kong, Japan, South Korea and Taiwan.

Photo Caption

The coal yard of the Qinhuangdao coal harbour, the largest coal harbour in China, occupies an area of 205,000 square metres with a storage volume of about 1.5 million tons. The coal yard was built in the third phase of construction.

1990-1995 S&T Development Plan for State-Owned Mines Detailed

906B0050A Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese No 2, 25 Feb 90 pp 2-16

[Article by Wu Yanfang [6762 1693 5364] of the Technical Development Bureau, China Unified Distribution Coal Mine Corporation: "An Explanation of the 1990-1995 S&T Development Plan Program in the China Unified Distribution Coal Mine Corporation"]

[Text] The 1990-1995 S&T Development Plan Program in the China Unified Distribution Coal Mine Corporation is based on the Medium and Long-Term Energy Resource S&T Development Program and on development goals for the China Unified Distribution Coal Mine Corporation during the Eighth 5-Year Plan suggested by Comrade Yu Hong'en [0060 3163 1869], and were formulated after soliciting opinions from the relevant provincial bureaus, mining bureaus, and various industrial bureaus in the corporation. It contains four parts: an introduction, development goals, key S&T tasks, and policies and measures.

The introduction provides background material for the plan program. It briefly describes the current situation in the coal industry, achievements and advances in coal S&T over the past 10 years, and problems that exist. It contains ideas at three levels:

The first level of ideas is a discussion of achievements in technical progress, including two areas. First is changes in the basic technical situation in coal mines, including establishment of four modernized mining bureaus, 32 modernized mines, and so on. Second is technical progress in the 11 areas of geological prospecting, mine design, mine construction, extraction technologies, mechanization of coal extraction, reforms in mineshaft support materials, mine safety technologies, shaft electrification and communications in coal mines, mine lifting and haulage, coal processing and utilization, and application of new technologies.

The second level of ideas is problems which exist in technical progress in the coal industry, which mainly involve four issues: 1) Low levels of technical equipment and the large amount of heavy physical labor; 2) a rather seriously high rate of safety accidents; 3) low labor productivity; and 4) low degrees of coal processing and utilization, and rather severe pollution from coal.

The third level of ideas is analysis of the causes for backwardness in coal mine technologies. There are five main reasons: 1) The price of coal is too low, so they lack strength to make technical advances; 2) substantial reductions in S&T inputs; 3) instability in S&T staffs; 4) a serious decline in the quality of workers; and 5) certain persistent problems in understanding. Everyone is rather clear about the content of this part, so it does not require further explanation. I will mainly explain the other areas.

I. Development Goals

Based on the development goals of the China Unified Distribution Coal Mine Corporation, the guiding ideology for S&T development plans in the corporation from 1990 to 1995 is: S&T work for coal should be oriented toward coal production and construction, focus on the three main aspects of coal industry production, construction, and economic diversification and on the three primary matters of safety, efficiency and modernized mine construction, and concentrate forces to study and resolve key technical questions which have significant socioeconomic benefits in mechanization of excavation and haulage, coal processing and utilization, and coal mine safety; develop multilevel technologies and be concerned with applied research and technical equipment; actively extend many broad-based new technologies with high benefits, strive for optimum technical

economic results, strive to attain previously established goals set for coal mines in full staff labor productivity, death rates per 1 million tons of coal, and raw coal output by 1995, and serve the goals of sustained, stable, and healthy development of coal production and construction. There are three levels of ideas here. The first level concerns the orientation of coal S&T work. It should be oriented toward the three main aspects and three primary matters in the coal industry. The second level of ideas concerns the focus of coal S&T work. This should be dealing with key technical questions with significant socioeconomic results involved in mechanization of excavation and haulage, coal mine safety, and coal processing and utilization. The third level of ideas concerns the need to make deep deployments in coal S&T work, develop multilevel technologies, have applied basic and theoretical research and technical equipment, and actively extend new technologies.

Based on the development goals of the China Unified Distribution Coal Mine Corporation and the guiding ideology for S&T development, we proposed six goals for S&T development: 1) Resolve to a significant extent urgent key technical problems in production and construction; 2) base most of the primary technical equipment involved in coal mining on domestic supplies. Tunneling and safety equipment should exceed Poland's technical standards and we should strive to attain world standards of the early 1980's; 3) make rather obvious improvements in technical economics indices; 4) achieve a substantial improvement in coal mine safety; 5) make substantially deeper deployments for scientific research; 6) set goals in the areas of S&T measures and S&T staff construction.

These guiding ideologies and development goals are successful experiences and important development principles which practice has proven can promote development of the coal industry and S&T, whether in regard to the three main aspects and three primary matters or multilevel technologies and deeper deployments of scientific research work. Thus, it is entirely necessary that we conscientiously adhere to these principles during the Eighth 5-Year Plan. Below, I will explain these development goals in terms of labor productivity, death rates per 1 million tons, and surpassing Poland's technical standards in excavation mechanization and safety equipment, as well as striving to attain world levels of the early 1980's.

Labor productivity is a synthetic indicator that can be used for comprehensive evaluation of S&T progress and scientific management levels in an industry or sector. Before 1986, full staff labor productivity in China's coal mines never surpassed 1 ton. Since 1981, however, along with technical progress and rationalization of labor organization in coal mines, full staff labor productivity began to assume a trend toward stable increases, rising from 0.87 ton/manshift in 1981 to surpass 1 ton/manshift in 1986 at 1.001 tons/manshift, and then increasing to 1.053 tons/manshift in 1987 and 1.092 tons/manshift in 1988. Statistics for the China Unified Distribution Coal Mine Corporation give figures of 1.11 tons/manshift in 1988 and 1.149 tons/manshift for the first 9 months of 1989. The projected figure for 1989 is 1.15 tons/manshift.

According to information provided by labor organization departments, these are the reasons for the increase in labor productivity over the past few years: From 1985 to 1986, labor productivity grew by 6.6 percent, with increased output accounting for 1.81 percent and reductions in employees accounting for 4.79 percent. From 1986 to 1987, labor productivity rose by 5.89 percent, with increased output accounting for 1.5 percent and reductions in employees for 4.39 percent. From 1987 compared to 1988, labor productivity rose by 3.7 percent, with increased output accounting for 2.2 percent and reductions in employees for 1.5 percent. During the first 9 months of 1989, labor productivity rose by 3.89 percent compared with the same period in 1988, with increased output accounting for 4.11 percent and reductions in employees for -0.22 percent. Examining the factors behind increasing labor productivity over the past few years, one sees that reductions in employees is the main factor, but its role has decreased each year, even to the extent of becoming a negative number. This means that rational labor organization and reductions in raw coal workers plays an important role in raising labor productivity and that there is still potential, but with definite limits. Thus, if we wish to increase labor productivity in the future, apart from continuing to focus on scientific and rational labor organization and controlling the number of employees, we also should expend considerable effort on using technical progress to increase output.

Looking at the relationship between the increase in full staff labor productivity and increases in the degree of mechanization in coal extraction over the past few years, the ratio between a 1 percent increase in full staff labor productivity and a 1 percent increase in degree of mechanization in coal extraction has dropped from the rather high figures of 1.4 to 1.68 over the past few years to 1.04, meaning that the effects of an increase in the extent of mechanization in coal extraction on full staff labor productivity has been gradually reduced. Thus, to increase full staff labor productivity, increasing the degree of mechanization in coal extraction should be combined with rational concentration of production and increases in unit output and unit progress. It also requires a focus on the degree of mechanization in tunneling, haulage, and auxiliary activities, reductions in safety accidents, and construction of more modernized mines and shafts. Moreover, attention should be given to automation of several links in modernized mines. Attacks on key S&T topics and projects to extend new technologies in the plan program were arranged around these questions.

The death rate per 1 million tons of coal is a comprehensive indicator of the situation in coal mine safety technology management as well as an important indicator of coal mine characteristics. There has been a rather substantial drop in the death rate per 1 million

tons in China's coal mines since 1979. The death rate per 1 million tons in China's unified distribution coal mines dropped at an average annual rate of 10 percent between 1979 and 1988. Statistics from the China Unified Distribution Coal Mine Corporation show that it dropped an average of 15 percent yearly between 1985 and 1988.

The main areas where accidents occur at the present time are still: 1) Roofs, accounting for about 40 percent; 2) haulage, accounting for about 20 percent; 3) gas, accounting for 13 percent; and 4) electromechanical, accounting for 10 percent. However, gas accidents are responsible for the greater proportion of deaths in major accidents, accounting for over 45 percent. Unified distribution coal mines now have more than 130,000 people suffering from pneumoconiosis and about 9,000 additional cases of pneumoconiosis occur annually. Almost half of the mines under jurisdiction of the China Unified Distribution Coal Mine Corporation are coal and methane eruption mines and high methane mines, one-half are naturally combustible mines, and more than 80 percent of the mines have a risk of coal dust explosions. To deal with this situation, the former Ministry of Coal Industry and the corporation have concentrated on three main links to solve safety problems in the past few years: 1) Focusing closely on the central link of gas and coal dust; 2) solving numerous and widespread roof, lifting, and haulage accidents; 3) controlling the latent risk of pneumoconiosis. They have resolutely focused on both equipment and management. In the area of equipment, preventing gas and coal dust accidents mainly involves controlling gas and coal dust explosions, reinforcing prevention of gas eruptions, improving mine ventilation, improving environmental monitoring measures, controlling fire sources, accelerating modernized construction of emergency equipment, and so on. Preventing roof accidents mainly involves improving roof support technologies and gradually shifting from friction metallic support columns to single hydraulic support columns, and so on. Preventing lifting and haulage accidents includes gradually improving outdated and complicated lifting equipment, replacing electric powered carts lacking explosion preventions, installing personnel haulage cars for inclined shafts, car runaway prevention equipment, and so on. To attain the previously specified goal of reducing the death rate per 1 million tons, attacks on key problems and new technology extension projects in the plan program also focus on these types of technical equipment.

As for the question of exceeding Poland's standards, I will prepare to describe it in terms of the two areas of comprehensive technical economics indicators and technical standards for excavation equipment. Poland is one of the world's main coal mining nations. Its commodity coal output in 1987 was 193 million tons of hard coal and 73.2 million tons of lignite, equivalent to 255 million tons and 97 million tons of standard coal, extracted, respectively, in shaft mines and open-cut mines. Poland began developing common mechanization in the 1960's and began developing fully mechanized mining in the 1970's. In the late 1950's, however, it began to concentrate production. Now, 193 million tons of its commodity coal is produced by 70 shaft mines, each mine producing an average of nearly 3 million tons of commodity coal, equivalent to about 3.6 million tons of standard coal. Centralization of production created excellent conditions for developing mechanization and the degree of mechanization rose very quickly from 34.1 percent in 1960 to 66.7 percent in 1965, over 90 percent in 1975, and 97.8 percent in 1987. The extent of fully mechanized coal mining was 3.8 percent in 1970 but had grown to 90.6 percent by 1987. Fully mechanized tunneling now accounts for more than 50 percent of coal shaft tunneling. Full staff labor productivity was 2.34 tons/manshift in 1983 and 2.5 tons/manshift in 1985, equivalent to 3.1 tons/manshift and 3.3 tons/manshift of standard coal, respectively. The death rate per 1 million tons of coal for the past 7 or 8 years has averaged only about 0.5 to 0.6 people, equivalent to 0.38 to 0.45 people when converted to standard coal. Because of actual conditions in China like the rather large number of medium-sized and small mines, China's coal mines, which includes unified distribution coal mines, must continue to develop multi-level technologies during the Eighth 5-Year pLan, and the extent of production centralization and mechanization will still lag considerably behind that in Poland. Thus, not all coal mines will be able to catch up with Poland's standards in comprehensive technical economics indices. China now has four modernized mining bureaus and 32 modernized mines. The full staff labor productivity for this group of mines has reached 2.947 tons/manshift. According to data for 1988, it reached 5.44 tons/manshift in Wangzhuang Mine. The degree of mechanization in coal extraction exceeds 90 percent, and has reached 100 percent in many. The extent of fully mechanized extraction exceeds 60 percent in all of them. This includes 100 percent at Xinglongzhuang Mine and Wangzhuang Mine, and 90 percent at Tancun Mine, Gushuyuan Mine, and Shigejie Mine. Fully mechanized tunneling generally exceeds 20 percent. It exceeds 50 percent at Wangzhuang Mine and Xinglongzhuang Mine. The death rate is just 0.35 people per 1 million tons of coal. Already completed modernized coal mines are also formulating regulations for a push toward high standard modernized mines. Tancunzhuang Mine and Gushuyuan Mine, for example, plan to work toward a single fully mechanized mining team and two fully mechanized tunneling teams for a single mine, yearly output exceeding 2 million tons, and a full staff labor productivity of 8 to 10 tons/manshift. It is apparent that modernized mines which will be completed near the end of the Eighth 5-Year Plan may catch up with and surpass Poland's standards in technical economics indicators.

Looking at technical levels for extraction equipment, in the areas of roller coal extractors, hydraulic supports, and medium-sized scraper conveyors, there is not a great deal of difference between technical standards in China now and those in Poland, but there is a definite lag in certain areas with some equipment. For example, Poland now has heavy scraper conveyors with a 1,000 tons/hour

grade capacity, but they are still being developed in China. Poland already has large-pitch (60°) roller coal extractors and hydraulic supports. Although China has them, they have not undergone production testing. Poland's newly produced KGS-260 coal extractors have several sensors installed on them for such things as roller electromechanical coil groups, oil temperature, oil and water pressure, current, traction speed, and so on. As soon as these parameters exceed their limits, the power to the coal extractor is shut off automatically. As for the reliability of equipment from Poland which is being used in China, the coal extractors and conveyors are relatively sturdy and reliable. This is particularly true for coal scrapers, which have developed rather quickly in Poland in recent years and come in quite a variety of products. The power of the electric drive machinery for the scraper heads is now as high as 2 X 200 kW. China, in contrast, has a limited variety of coal scraper products and the power of the electric drive machinery for the scraper heads is only 2 X 40 kW and 2 X 75 kW. Quite a bit of work remains to be done on the scraper head and other components, position switches, and so on. China of course should be somewhat stronger than Poland in the area of electrical equipment for coal extraction machinery, so China is responsible for developing the electric traction for the thin coal seam electric traction coal extractors cooperatively developed by China and Poland. In the area of tunneling equipment, besides the AM50, Poland is already capable of manufacturing heavy fully mechanized tunneling machines with an installed capacity of 2 X 160 kW, and the drilling cars and side-dumping rock loaders used for rock tunneling have now been systematized. China's product varieties lag substantially behind theirs. According to arrangements in the Eighth 5-Year Plan, if projects to attack key problems proceed smoothly, we may be able to surpass Poland's standards during the later part of the Eighth 5-Year Plan in technical standards for excavation machinery.

A great deal of work must be done before our excavation machinery and equipment can attain world levels of the early 1980's. The 100 complete sets of fully mechanized extraction equipment (including tunneling machines, etc.) China imported in 1979 are representative of world technical levels in the mid- and late 1970's. After undergoing digestion, copying, and attacks on key problems in scientific research, manufacturing, and applications departments over the past 10 years, the performance of China's excavation machinery has basically attained foreign levels of the mid- and late 1970's, but we lag considerably behind in the reliability and useful life of hydraulic, electrical control, and other components. In the area of product varieties, besides having formed product series for hydraulic supports, coal extractors, and face conveyors, we lack many types of equipment like coal scrapers, heavy tunneling machines, and so on. There also were quite a few new developments in excavation machinery in foreign countries during the early 1980's. The primary indicators for these are: the maturation of electric traction coal extraction technologies and formation of product series; the start of extension and application of electronic hydraulic control technologies for hydraulic supports; heavy face conveyors with a haulage capacity of 1,500 tons/hour and a haulage distance of 250 meters which can handle 2 to 3 million tons of coal; powerful high power tunneling machines capable of cutting hard rock (f = 8-10), electromechanically integrated electrical control systems, and so on. These technologies have played important roles in promoting high output, high efficiency extraction faces and modernized mine construction and they have been widely implemented. China may be able to attain and approach world levels of the early 1980's through attacks on key problems during the Seventh and Eighth 5-Year Plans to reduce the difference between technical levels for China's excavation machinery and equipment to about 10 years.

II. Explanation of Projects To Attack Key S&T Problems

The principles for arranging projects to attack key S&T problems this time are: 1) Suggest several major technical problems to solve in the near term based on the spirit of State Planning Commission notices "On Some Major Issues in Economic Development Strategies for the Year 2000" and "Views on Arranging Work To Compile a National Key S&T Topics Attack Plan for the Eighth 5-Year Plan" and the Energy Resource Medium and Long-Term S&T Development Program. 2) Focus closely on development goals whose attainment has been proposed by the China Unified Distribution Coal Mine Corporation, promote coal mine modernization, and gradually and effectively solve key technical problems with major socioeconomic benefits in mechanizing excavation and haulage, coal mine safety, and coal processing and utilization. 3) Achieve a prominent focus on development levels for multi-level technologies in arranging actual projects and avoid dispersal of efforts. Topics should focus on crucial issues and key technologies while sticking resolutely to limited goals and not trying to attend to each and every aspect of a matter. We should try to integrate the related capital construction, technical transformation, technology importing, and S&T cooperation plans, link them together, and make comprehensive arrangements.

In accordance with these principles, we only arranged 50 projects to attack key topics this time. All the projects which must be solved by attacks on key problems and some projects were included among regular corporation projects and arrangements were made for them in annual plans. Several projects in the soft sciences and basic theoretical projects which were very important but which concern a broad range of areas and which are difficult to carry forward by outlining them one after the other were left for future annual plans. At the same time, several questions that concern only certain bureaus or mines should be included in provincial and bureau plans for attacks on key topics to form key S&T topic attack plans divided by levels.

Next, these 50 key topic projects will be described in the six categories of extraction, tunneling, safety, geology, electrification, and processing and utilization.

A. Extraction Technologies

Mechanization of coal extraction. After a long period of work, we have now formed or begun to form extraction methods and complete sets of equipment for different levels of fully mechanized extraction, high-grade common extraction, and common extraction for seam-by-seam extraction of gently dipping medium thickness coal seams, thick coal seams, and extra-thick coal seams. The maximum power of the coal extractors is 2 X 300 kW (2 X 375 kW), the maximum power of face conveyors is 2 X 250 kW, and the maximum bracing capacity of single hydraulic supports has reached 1,000 tons at heights of 0.55 to 5 meters. The product varieties and performance of all types of equipment basically satisfy coal mine production requirements. The most acute contradictions at present are rather poor reliability and relatively high breakdown rates, so there need to be more attacks on key problems with certain components. The main problems in production are: 1) Low machine operating rates at faces (the national average for fully mechanized faces is only about 17 percent and 27 to 35 percent for 1 million tons/year fully mechanized mining teams); 2) low equipment utilization rates (there are 445 sets of fully mechanized extraction equipment in China and an average of 216 fully mechanized extraction faces, a utilization rate of only 48.5 percent); 3) there is an urgent need to solve problems in mechanizing extraction in several hard-to-mine coal seams. For this reason, beginning in 1990, which includes the Eighth 5-Year Plan, we plan mainly to carry out work to attack key S&T problems to deal with these questions.

1. Increase the reliability of fully mechanized extraction, high-grade common extraction, and common extraction equipment to raise the face equipment operating time by 20 percent above present levels. Improve the performance and reliability of hydraulic traction coal extractors, face scraper conveyors, and belt conveyors to achieve high-power coal extractors which can mine 1 million tons of coal and which do not require major overhauls after cutting 500,000 meters of coal, medium-power coal extractors which can mine 600,000 tons and which do not require major overhauls after cutting 300,000 meters of coal; heavy face scraper conveyors which have central troughs capable of handling more than 2 million tons; and using increases in the reliability and support moving speed of face hydraulic supports to enable normal operation for 3 years without major overhauls and a support moving speed under normal conditions of no more than 15 to 20 seconds/support.

Work to attack key problems with equipment, technologies, and systems as well as work to strengthen management, technical training, and so on have brought a greater than 20 percent improvement in machine operation times for fully mechanized faces. This will also lead to a rather substantial increase in unit output levels. Estimates based on the average national fully mechanized machinery operation rate of 17 percent indicate a daily machine operation time of about 4.1 hours. Increasing the rate to 20 percent would raise the operation time to about 5 hours. This could increase average unit output by 7,000 to 8,000 tons/unit/month. With over 200 fully mechanized faces in China, this could raise yearly coal output by about 15 to 20 million tons.

2. To increase the utilization rate of fully mechanized mining equipment, we should provide new technologies to reduce the number of moves and speed up moving. Fully mechanized mining equipment comes in large numbers and weighs in the tons. Each set of equipment used for heavy support faces, for example, weighs 1,800 to 2,100 tons and the transport distance for moves is generally 2 to 3 kilometers. This now depends mainly on small pit carts and takes 25 to 40 days and 4,500 to 8,700 man-hours on the average for each move. Some take as much as 15,000 man-hours. With each fully mechanized mining team moving an average of 1.2 to 1.5 times a year, this takes up 1 to 2 months. Federal Germany and England take only 2 to 3 weeks to move and require 400 to 500 man-hours. The moving time in the United States and Australia generally takes only 1 week and requires about 100 man-hours. It is apparent that the actual efficiency in moving fully mechanized faces in foreign countries is several to several tens of times greater than in China. For this reason, one thing we must do is resolve rational face deployment patterns and extraction technologies such as developing space-following tunnel-leaving pillarless extraction and tunnel protection technologies and studying the adoption of modern tunnel protection materials, technologies, and associated equipment. The second thing is to develop high efficiency auxiliary haulage equipment matched up with fully mechanized excavation and focus on solving problems with auxiliary haulage machinery in extraction regions.

We should work in these two areas to reduce the number of moves and accelerate moves. Fully mechanized mining in China now moves more than 400 times each year. Reducing the time spent on each move by about 15 days could substantially reduce the number of employees and the shutdown time required for moving and increase coal output.

3. Solve problems of mechanizing some hard-to-extract coal seams. There are quite a few problems to be solved in hard-to-extract coal seams. Scientific research projects during the Sixth and Seventh 5-Year Plans to solve key problems have already begun working on single-pass full-height complete sets of fully mechanized mining equipment and technologies for "three soft" and "three hard" 4.5 to 4.8-meter-thick coal seams, steeply inclined fully mechanized mining equipment, roof-emplacement coal extraction technologies and equipment for extra-thick coal seams, and so on. When they are extended and applied in the future, they also should be perfected and improved. During the Eighth 5-Year Plan we are focusing on mechanizing thin coal seam extraction. Thin coal seam reserves account for about 20 percent of

China's recoverable reserves but now comprise only 12 percent of output. This is especially true for mining regions with a higher degree of mechanized coal extraction where the lack of coordination in matching extraction of thin and thick coal seams is becoming increasingly acute. For this reason, there is an urgent need to develop mechanization of thin coal seam extraction to increase coal output and labor efficiency in thin coal seams and improve working conditions. Attacks were made on key S&T topics during the Sixth and Seventh 5-Year Plans and definite advances were achieved, for example the extension and application of BM-100 and other thin coal seam coal extractors, but the great technical difficulty and insufficient funds meant that the degree to which they were solved lags far behind meeting on-site requirements and the scope of utilization is rather narrow. During the Eighth 5-Year Plan, we will attack key problems with three technologies, coal scrapers, hydraulic traction, and electric traction roller-type coal extractors, strengthen development of coal scrapers, and try to solve problems with thin coal seam extraction machinery for extraction heights over 0.7 meters and powers of more than 150 to 200 kW.

Hydraulic coal extraction is an effective way to mechanize some hard-to-extract coal seams. China began developing hydraulic mining technologies rather early and they are relatively mature. We are in the advanced ranks of the world. Their range of applications has been expanded to all types of steeply inclined coal seams and unstable coal seams. During the Eighth 5-Year Plan, we plan to focus on "economical" hydraulic mining technologies and systems suitable for use with unstable coal seams and the production characteristics of mining regions with smaller production capacities. We are studying in-shaft coal-mud-water condensing processing and technologies for closed loop cycling and re-utilization of water supplies and system and equipment simplification to attain about a one-third savings of capital construction costs per set of equipment and a 50 to 60 percent savings of compensation water compared with existing conventional hydraulic mining technologies and systems.

4. High output, high efficiency fully mechanized extraction faces at the 10,000 ton daily output level. Continually improving unit output and unit efficiency of fully mechanized mining faces in stages and by levels have been a goal of struggle and content of attacks on key problems in the world's main coal producing nations for the past several years. Complete sets of fully mechanized mining equipment at the daily output level of 10,000 tons of raw coal have successively gone into production, with obvious benefits. (Luohuofe) Coal Mine in the Federal Republic of Germany's Ruhr mining region put two sets of fully mechanized mining equipment into operation in 1981 and 1986 and attained average daily commodity coal outputs of 6,000 tons and 5,500 tons, respectively, and a maximum daily commodity coal output of 13,600 tons. (Ensitafu) Mine in Federal Germany installed two sets of fully mechanized mining equipment in 1987 and they have reached daily commodity coal output levels of 12,500 tons. Statistics from 1987 show that the United States has over 20 fully mechanized mining faces with daily raw coal outputs in excess of 10,000 tons. Maximum raw coal outputs of more than 20,000 tons per day and 10,000 tons per shift have occurred. They set world records of 330,000 tons in monthly output and yearly output of 2.5 million tons of raw coal. Fully mechanized mining faces with daily outputs of about 10,000 tons have appeared in Australia, South Africa, and France. Average monthly output levels for fully mechanized mining faces in China are about 40,000 tons and 26 fully mechanized mining teams have yearly outputs in excess of 1 million tons. Average daily outputs are about 3,000 to 4,000 tons. The No 1 fully mechanized mining team at Wangzhuang Mine in the Luoan Mining Bureau produced 1.7 million tons in 1987 with a maximum monthly output of 159,000 tons. The Youth fully mechanized mining team at Gushuyuan Mine in the Qincheng Mining Bureau created a national standard for yearly output of 18.011 million tons in 1988 and had an average daily output in excess of 5,000 tons. Thus, whether we are speaking of developments in foreign countries or meeting needs in China and foreign countries, work to move fully mechanized mining equipment up to a new stage and develop fully mechanized mining equipment at the 10,000 tons/day output level in China's mining regions which have the proper conditions is very necessary. However, in looking at the current situation in China in development of fully mechanized mining equipment, the difficulty is very great and we still must attack many key technical problems. In equipment capacity, production efficiency, reliability, useful lifespans, diagnosis and monitoring technologies, and other areas, none can meet the requirements for 10,000-ton daily output levels, so we must develop complete sets of fully mechanized mining equipment with high production capacities. In consideration of the technical difficulty, we should take two steps. We will begin to take the first step during the Eighth 5-Year Plan, which mainly involves improving the reliability of existing equipment, developing large-capacity face and along trough conveyors, rapid support moving systems for hydraulic supports, and adopting compound power supply patterns to attain daily output levels of 7,000 to 8,000 tons, monthly outputs of 200,000 tons, and yearly outputs of more than 2 million tons for fully mechanized faces. The second step, which comes during the Ninth 5-Year Plan, is to complete the development of large-capacity equipment, place full sets of fully mechanized mining equipment with an hourly production capacity of more than 1,500 tons into normal operation, enable trough-following control of coal extraction face equipment, attain daily output levels of 10,000 tons, and catch up to advanced international levels of the 1980's.

5. The question of mining pressurized coal beneath villages is a serious problem that is common throughout coal mine production in China. According to incomplete statistics, there are over 5 billion tons of pressurized coal beneath villages in unified distribution coal mines and it

comprises over one-half [of reserves] in the mining region located in the plain covering Hebei, Shandong, Anhui, Henan, and Jiangsu provinces. For a long time, mining pressurized coal beneath villages mainly involved moving the villages. Because of the growing costs of moving villages and the amount of cultivated land occupied, the effects on ecological equilibrium, tense relations between industry and agriculture, and even tensions over mine reclamation, a situation of falling output and cessation of output has appeared. Experiments with mining without moving villages were conducted during the Sixth and Seventh 5-Year Plans. In Xingtai, Yangquan, Zijiang, and other mining regions, houses with deformation-resistant structures were built locally first and then extraction was carried out. Rather satisfactory results were attained in mining coal beneath villages which were not endangered by water or where phreatic water levels were low. At present, besides working to perfect and improve experiments with local construction of houses with deformation-resistant structures, there is an urgent need to solve problems involved in mining without moving villages to enable the extraction of coal beneath villages with high phreatic water levels in Huaibei, Xuzhou, Heicheng, Zaozhuang, Yanzhou, Datun, and other mining regions. During the Eighth 5-Year Plan, we plan to use coal gangue and pulverized coal ash to create land for building villages and for fill as well as other technical measures in an attempt to open up a more effective technical route for mining coal over a wide area beneath villages with high phreatic water levels.

6. In the area of open-pit mining, strip mining has many advantages. Compared to shaft mining, the relative scale is larger, costs are lower, efficiency is higher, and the recovery rate is higher. The proportion of open-pit mines in China is small, however, less than 5 percent. We have built several new strip mines and adopted many new technologies in the past few years. Examples include continuous extraction technologies using medium and small-scale equipment sets, single bucket and truck technologies using large equipment sets, internal earth spreading technologies, and so on. We have basically grasped non-work assisted side slope stabilization laws and medium and long-term side slope monitoring technologies. Open-cut extraction is the direction of future development and we now plan to build strip mines for yearly output of 80 million tons. In the area of extraction technologies, we should adopt continuous extraction, semi-continuous extraction, comprehensive extraction, and other new technologies. All producing strip mines now have problems with side slope stability and we must deal with short-term monitoring and side slope stability of earth dumping grounds with loess foundations and safety questions regarding surface structures. The depth of extraction in some strip mines is considerable, and deep ventilation problems have already appeared. These must be gradually solved through attacks on key problems during the Eighth 5-Year Plan.

B. Reforms in Rapid Shaft Tunneling and Excavating Standard Shaft Support and Protection Technologies

The requirement for the year 2000 is 1.4 billion tons in coal output, of which 200 million tons in additional capacity will depend on building new unified distribution coal mines. Estimated according to the current amount of annual tunneling engineering in unified distribution coal mines, the amount of shaft engineering will reach 10,000 kilometers by the year 2000. Thus, the shaft construction tasks are very arduous and the amount of shaft engineering great. The current situation is that average monthly progress in rock tunnels by the China Unified Distribution Coal Mine Corporation is about 60 meters. Average monthly progress in coal tunnel blasting is about 150 meters. Average monthly progress in mechanical coal shaft tunneling is about 300 meters. There is a major problem. Just as Comrade Yu Hong'en has pointed out repeatedly, "tunneling equipment is rather backward and matchup is rather poor," so the speed and efficiency of tunneling cannot meet the needs of development.

During the Eighth 5-Year Plan, work will be done mainly in these four areas:

1. Perfecting and improving existing common shaft drilling technologies and reinforcing research on tunnel and tunnel wall support and protection technologies for special types of strata. Substantial developments have been achieved in common construction technologies for vertical shafts after several years of efforts, and we can now provide equipment sets for common tunnel drilling of tunnels with net diameters under 8 meters and shaft depths under 700 meters. Still, the average monthly shaft drilling speed in China is still less than 30 meters. The main technical problem is that one or more water-bearing strata must be passed through during the drilling of most tunnels. The water surges can reach 100 to 200 cubic meters/hour. However, forecasts of geological and hydrological conditions are inaccurate and grouting technologies to stop the water are imperfect, which causes severe effects from drenching. At the same time, the shaft drilling equipment is unreliable and breaks down quite often. The effects of accidents often take up about one-third of the working time. For this reason, we must accurately forecast hydrological and engineering geology conditions in tunnels and work to effectively control water surges, implement "dry shafts" drilling, and increase the reliability of primary shaft drilling equipment to speed up shaft drilling and strive to achieve a monthly shaft progress rate of 50 to 60 meters.

Over the past several years, destruction of tunnel walls due to rupturing and flaking has occurred in 14 tunnels at nine mines in tunnels in special strata from the Huainan-Huaibei to Xuzhou-Peixian regions (including 13 built using the freezing method and one built using the shaft drilling method). These seriously affect mine production and safety. At the same time, several new mines with similar conditions must be built in this region. For this reason, we should analyze and monitor

the causes for tunnel wall destruction to propose measures for locally reinforcing tunnel sections with concentrated stresses and fully reliable opinions on monitoring and analysis, suggest tunnel structures and basic design methods adapted to strata deformation, and search for basic methods to prevent damage to tunnel walls.

2. Improve the reliability and completeness of key equipment used to drill rock tunnels. Horizontal rock shaft tunneling has now formed a three-level set of technologies. One uses mainly scraper bucket rock loaders suitable for small cross-section shafts (under 8 meters square). The second uses mainly side-dumping rock loaders suitable for use in large and medium cross-section (8 square meters and larger) shafts. The third is full cross-section rock tunnelers. Complete technologies which mainly use side-dumping rock loaders have developed rather quickly in the past few years and they are in common use in foreign countries. In China, Kailuan, Xingtai, and Xuzhou are using entrance hydraulic rock drilling platform trucks (or components) matched with Chinese-made side-dumping rock loaders. They surpassed monthly tunneling rates of 200 meters or more four times, revealing the development potential. For this reason, we should improve the reliability of primary equipment and components during the Eighth 5-Year Plan, basically achieve domestic production of imported components, and attain a useful life of 1 year without having to pull them from the shaft for major overhauls. At the same time, we should further perfect pre- and post-matchup and increase the overall capacity.

China has been using roof bolt spray support and protection technologies for 30 years now. Statistics indicate that they support a total of 13,400 kilometers of shafts and are now increasing at an annual rate of about 1,000 kilometers, one-half of tunneled rock shafts. However, several technical problems have not been resolved. One is that support designs continue to rely on experience and engineering comparisons. A second is the large amount of powdered ash in spray concrete construction (in most cases about 100 mg/cubic meter) and high resiliency (30 to 50 percent in most cases). A third is the absence of effective control and monitoring measures for engineering quality. We should continue to concentrate forces during the Eighth 5-Year Plan, attack key problems focused on these issues, and achieve new developments in roof bolt spray support technologies.

3. Strive to raise coal and half coal-half rock shaft tunneling technologies to a new level. Through work over recent years, five different types of coal and half coal-half rock tunnelers have been formulated (AM-50, S-100, EL-90, ELMB, and EZ75 models) and a batch production capacity has been formed for most of them. They can be used to tunnel coal shafts and f equal to or less than 6 half coal-half rock shafts at a monthly progress rate usually from 300 to 400 meters. The main problem now is the lack of improvements in some components, especially electrical control systems, hydraulic sealing components, and spray dust quenching systems which have poor reliability and suffer breakdowns. At the same time, there is a lack of adaptation of pre- and post-matching equipment which has restricted machine efficiency. Through attacks on key problems in the Eighth 5-Year Plan, we should achieve a useful life of 1 year without major overhauls and a yearly tunneling rate of 5,000 meters, and effectively solve problems with equipment matchup to meet the need to develop fully mechanized extraction. At the same time, in consideration of the needs of thin coal seam extraction and half coal-half rock shaft tunneling, we should develop large powers of 150 to 200 kW to adapt to attacks on key problems in $f = 8$ half coal-half rock shaft tunnelers.

4. Reforms in excavating standard shaft support technologies. The amount of shaft engineering annually in China's unified distribution coal mines is now about 7,000 kilometers, about two-thirds of which is excavating standard shafts. In excavating standard shafts, wood supports account for 21.7 percent and U-shaped steel supports for 9.3 percent. For the remainder, steel I-beams and rigid supports with other shapes are used in mines. The main problems are, one, an overly high proportion of rigid supports, which account for about 69 percent. The properties of the supports are not suited to the deformation laws of the surrounding rock and support results are poor. Shaft roof falls and sheet falls are common in the tunnels, causing serious bending damage to the supports and requiring frequent repairs. The second is excessive consumption of timber and steel, with steel and timber supports accounting for about 60 percent. This has prevented shaft support technologies from adapting to developments in fully mechanized mining and mechanization of tunneling. The world's main coal producing nations basically do not use rigid supports. There are two main types of supports used in excavating standard shafts. One is in European nations, which mainly use U-shaped steel collapsible supports. These account for over 90 percent of the supports used in Federal Germany and Poland and are used to adapt to the relatively complex geological conditions, great extraction depths, large pressures, and other characteristics of these nations. The second type is the roof bolt supports commonly used in the United States and Australia. They are adapted to the simple geological structures, small extraction depths, relatively stable roofs, and other characteristics in the United States and Australia. These trends will not change in the short term. On the basis of China's conditions and experiences, roof bolt supports are a technology with development prospects in excavating standard shafts. In some situations, they can be substituted for timber supports, steel I-beams, and other rigid supports. Metallic collapsible supports can substantially save timber and replace some steel. At the same time, we should perfect and develop U-shaped steel and steel I-beam collapsible supports and supports of other shapes and materials. For this reason, we should focus on two areas during the Eighth 5-Year Plan. The first area is to focus on R&D for roof bolts and combined roof bolts (roof bolt girders, roof bolt girder grids, and truss roof bolts) suggest experiments for different types

of shafts according to the conditions and scope of applications in China, and solve questions of structures, materials, parameters, and high efficiency matching machinery and tools for roof bolt support systems. In the area of technologies, we should reach a level of more than 20 percent in extension and utilization of roof bolt supports for extraction tunnels and pit timber consumption should be reduced 20 to 30 percent compared to the Seventh 5-Year Plan. Second, we should improve and perfect U-shaped steel and collapsible steel mine supports, improve support results, and suggest support regulations and quality monitoring measures.

C. Mine Safety Technologies

Reinforced labor protection and safe coal mine production are important issues in the coal industry. Failure to deal with these issues well will substantially restrict development of the coal industry. Unified distribution coal mines have adopted several measures over the past few years including major efforts to extend substitution of single hydraulic supports for metallic friction supports and, in the area of technologies, adopting improved gas exhaust technologies, regional coal and gas eruption prediction and forecasting technologies, comprehensive dust control technology systems, and beginning to establish environmental monitoring systems and other detection instruments and devices in high methane and gas eruption mines. We should achieve an obvious improvement in safety and production conditions in coal mines and reduce the death rate per 1 million tons each year. However, the serious situation in coal mine safety of many accidents, large number of injuries, and increasing pneumoconiosis has not been basically eliminated. The number of deaths and death rates far surpass those in the world's main coal-producing nations. This is particularly true of the frequent occurrence of major vicious accidents. During the Eighth 5-Year Plan, besides arrangements already made to mechanize excavation, the content of attacks on key issues to reduce roof and haulage accidents should focus on reinforcing work to attack key problems in comprehensive control technologies for coal mine gas, dust, and fires and strive to achieve a basic grasp of technologies for preventing major vicious accidents.

In the area of preventing gas explosions, we should further improve and perfect quantitative gas prediction technologies during geological exploration, formulate unified national methods and regulations for calculating gas surge amounts and raise the accuracy of predictions to more than 85 percent. We have basically solved problems with gas surges in adjacent strata in the past few years. However, pillarless extraction is used at many fully mechanized faces and we must solve problems with discharging gas in adjacent strata during oblique drilling. Fully mechanized faces involve powerful extraction, progress quickly, and have long strikes, so it is hard to solve gas problems by relying only on ventilation capacity. We should solve leading reinforced gas exhaust methods and technical equipment including long directional longitudinal boring (over 400 meters) drilling technologies to expand the scope of gas exhaust and increase the amount of gas discharged to achieve about a 10 percent increase in the exhaust rate. We should establish coal shaft tunneling ventilation and safety protection systems and eliminate sources of fire which cause explosive destruction.

In the area of preventing coal and gas eruptions, the quality and matchup of technical equipment are rather backward and we began working on prediction and forecasting technologies rather late. The conditions for which they are suitable are limited, so they should be intensified. Thus, on the one hand we should further perfect prediction and forecasting technologies and achieve multiple parameters and continuous forecasting. On the basis of comprehensive analysis of all types of eruptive mine situations, we should suggest methods and indices for categorizing risks and control measures. On the other hand, we should study prevention technologies and equipment for fully mechanized extraction and mechanized tunneling adapted to eruptive coal seams and ways to mechanize rapid extraction of thin and ultra-thin liberated strata. At the same time, for several extremely difficult coal and gas eruption mines like Liuzhi, Yingganling, and others, we should further develop research on comprehensive control to substantially reduce the number of eruptions and increase the tunneling speed and extraction speed in eruptive coal seams.

In the area of technologies to control the danger of dust, much work was done in the past regarding comprehensive prevention of all dust, but inadequate attention was given to respiratory dust which causes pneumoconiosis. For this reason, we should focus on comprehensive control of respiratory dust during the Eighth 5-Year Plan and first of all reinforce research on monitoring techniques to control the quality and output of respiratory dust. This includes developing high efficiency purification and dust reducing equipment and technologies suitable for use with mechanized coal mining and mechanically excavated faces. Also, after attacking key problems, ventilation patterns and control equipment for dust-bearing air flows should reduce dust concentrations at coal extraction and tunneling faces by 80 to 90 percent, including a more than one-half decrease in respiratory dust. We should strive to use technology to prevent increases in the number of people afflicted with pneumoconiosis. At the same time, we should continue to develop research on treating coal mine pneumoconiosis and laws of the causes of the disease and use a search for pathogenic and comprehensive treatment methods, administration of preventive drugs, and other attacks on key problems to attain the goal of controlling the development of the disease and improve dust prevention measures.

At the same time, we should improve and perfect existing explosion prevention and isolation technologies to expand their adaptability and increase the effects of their utilization.

In the area of technologies for controlling natural fires, China has one of the highest rates of natural coal mine fires in the world at 1.29 fires per 1 million tons of coal, with 90 percent of these fires started by natural causes. At present, although we can utilize certain indicator gases and beam tubes to predict natural fires, they can only be qualitative. For this reason, we should deal with quantitative determinations of the danger of natural fires and establish methods and indicators for predicting the shortest natural fire time. We should further improve comprehensive fire prevention technical measures for fully mechanized faces to mine coal from the roofs of thick coal seams and adopt flow-resistant chemical vapors, long-acting resistant chemical agents, and other new technologies to effectively control natural fires over a large area.

D. Geological Prospecting in Coal Fields and Mines

Through efforts over many years, we have basically grasped the distributional laws of China's coal resources and made an initial change in the backward situation in some prospecting measures. Digitalization of seismic prospecting has basically been achieved and we are gradually forming technical methods adapted to the characteristics of China's coal fields. Comprehensive application of new prospecting technologies and measures in recent years led to the discovery of Huainan Yingfeng, Shaanxi Shenmu, and other huge coal fields. At present, we should focus on making key S&T breakthroughs to adapt to the westward movement of prospecting deployments, liberate coal resources subject to flooding risks in old mining regions of east China, and provide reliable geological data for mechanizing coal extraction.

One, further clarify coal resources in west China's coal fields and prospects for their rational utilization. We should adopt modern geological theories, study strata, sediments, coal geology, and structural characteristics, conduct lithologic seismic prospecting, and other new comprehensive prospecting technology application work, and submit reports on coal accumulation characteristics and comprehensive resource assessments and development centered on west China's Shaanxi and Ordos coal fields.

Two, perfect and improve sounding technologies for small geological structures in mines. Substantial work has been done in this area in the past 10 years, and many types of instruments and methods have been developed. During the Eighth 5-Year Plan, the focus is on developing several types of sounding technologies like the pit penetration method, mine geology radar, and digital slot wave seismometers. This requires improvements in pit penetrometers, increased interference resistance performance and resolution, and a perspective distance of 350 to 500 meters. For mine geology radar, the leading sounding distance should be doubled to reach 60 to 80 meters, and we should achieve automated information processing and map plotting. Digital slot wave seismometers should solve problems with adaptability to coal seam geological conditions and microcomputerization of data processing to enable the attainment of a perspective distance of 800 to 1,000 meters and a reliability of more than 85 percent. Achieve a sounding precision that will enable location of single subsided pillars with a displacement no less than one-half the coal seam thickness and a diameter of more than 10 meters.

Three, deal with technologies for handling the danger of thick limestone strata karst water in extraction in mining regions of east China. Preliminary achievements have been made over the past 10 years in differentiating water sources for water eruptions, water eruption signs, and predicting the possibility of water eruptions. On this foundation, during the Eighth 5-Year Plan we plan to focus on developing research work on mine water eruption mechanisms, perfecting and improving comprehensive sounding technologies and rapid prediction systems, strive to establish a theoretical-empirical formula for the interrelated factors in water eruptions, delineate water eruption categories, establish 3- to 7-day water eruption prediction systems in two or three typical mines, enable prediction of the possibility of the occurrence of a water eruption 30 to 60 meters ahead of and to the left or right of a coal extraction face, and strive to use technology to ensure that "no shafts are flooded in major water eruptions and no deaths occur in minor water eruptions." At the same time, to clarify the hydrogeological situation in new areas of Panxie Mining Region and coordinate with supplementary prospecting projects, we should do research on coal field hydrogeological prospecting methods beneath enormously thick Cenozoic capping strata.

E. Coal Mine Electrification Equipment and Monitoring

For the past several years, to adapt to growing mechanization, 1,000 volt-grade power supply systems and associated equipment have been widely applied in mines. The reliability of electric motors used in coal extractors has been substantially improved, surpassing 2 years. We have developed many types of mine safety monitoring systems and microcomputer control systems for parts of the production environment. During the later part of the Seventh 5-Year Plan, we will implement communications system networks for all mines. There are now problems in two areas. One is the large number of breakdowns, short lifespans, and poor reliability of electrical equipment in mines and in electrical control systems for excavation machinery. Too few varieties of mine sensors have been developed and the quality has not been adequately improved. They cannot satisfy the needs of safety and production monitoring. Even less can they carry out monitoring (control) of the operating conditions of primary electromechanical equipment or implement health monitoring or breakdown diagnosis. The second area is the inability to interconnect mine monitoring systems and communications systems into networks. For this reason, attacks should be made on key problems in relation to these issues during the Eighth 5-Year Plan.

To improve the reliability of special-purpose electrical equipment used in coal mines, one thing we should do is achieve 1,000 hours of operation without breakdown in electrical control systems in tunnelers. Moreover, we should select one or two typical communications systems and switching protection devices to carry out reliability research, and we should formulate reliability indices, experimental methods, and quality control regulations, develop products which meet reliability requirements, and double or triple the degree of reliability. Second, we should develop intrinsically safe sensor components, intrinsically safe portable data collection devices, and so on with structures suitable for use in coal extraction face equipment. Third, our goal should be to guarantee safe and reliable operation of coal mining face equipment and raise the machine operation rate, and implement health monitoring and breakdown diagnosis for coal extraction equipment.

At the same time, we should solve problems with interconnecting monitoring (control) and communications systems, and form comprehensive dispatching guidance systems for full-mine production and safety monitoring to raise management levels in mines.

F. Coal Processing and Utilization and Environmental Protection Technologies

We have now developed jigging, weight screening, and flotation screening technologies and associated equipment with a yearly output capacity of 3 to 4 million tons and made considerable efforts to extend equal thickness screening, probability screening, and other new screening technologies. We have also adopted fluidized bed combustion, gangue power generation, using fluidized bed boiler slag to make concrete and construction materials, and other applied technologies which have played an important role in increasing the social benefits and economic benefits from coal mines. However, because these areas concern many fields and disciplines, environmental protection technologies began developing rather late, so there are many problems which must be studied and resolved, and this is very important. During the Eighth 5-Year Plan, we will only select certain problems which urgently require resolution and which the coal system is capable of solving to attack key problems.

One is coal desulfurization, which is essential. High sulfur coal accounts for more than 27 percent of China's reserves and there is extremely serious pollution after it is burned and discharged in some mining regions. We now discharge 15.2 million tons of SO_2 into the atmosphere each year. First, we should adopt attainable technical measures to remove inorganic sulfur and establish a high sulfur coal desulfurization system with an hourly capacity of 120 tons to reduce the sulfur content of the coal to less than 1.5 percent.

Second, we should improve the reliability of large-scale coal dressing equipment. At present, some large-scale coal dressing equipment like screening machines and centrifuges encounter various problems after less than 3 months' use. We should attack key problems regarding the wear resistance of key components and more than double their useful lives. At the same time, we should also implement on-line monitoring and closed-loop control of the systems to increase the cleaned coal output rate by more than 1 percent.

Third is comprehensive utilization of coal. This mainly refers to research on quality upgrade processing of young coal and joint refining technologies for coal and oil. We should employ new pyrolyzation technology systems and establish a quality upgrade processing pilot workshop with a yearly capacity of 20,000 tons. We should continue working to make improvements in two-segment water-coal gas boilers, complete a 2.26 meter diameter gasification furnace with a daily use output capacity of 3,000 Nm^3, and achieve ordinary pressure methanization to meet the needs of mining regions and small cities and towns. At the same time, we should strengthen research on preparation, pipeline transmission, and combustion technologies for coal-water slurry.

Four, we should deal with economically rational technologies for providing water to the 70 percent of China's mining regions which have water shortages and the 40 percent of our mining regions which have severe water shortages. We should develop control of mine water which contains salts, acids, and radioactive elements and strive to implement integrated engineering projects in several mines to attain the standards for industrial water supplies or drinking water supplies.

At the same time, we should continue to strengthen research on China's ever-growing gangue heaps and gangue utilization. Besides using gangue to control coal mine subsidence regions, we should also develop technologies which can consume large amounts of gangue like non-sintered bricks and making highway cement to provide additional technical routes for eliminating gangue heaps.

III. Extending 100 S&T Achievements

Projects to extend new technologies are an important aspect of the 1990-1995 China Unified Distribution Coal Mine Corporation's S&T development plan program. They are an obvious characteristic of this program. This was done in consideration of the need to rely primarily on existing S&T achievements and on experiences in each unit which practice has proven to be effective to achieve the corporation's development goals during the Eighth 5-Year Plan. These new types of equipment, new technologies, and new materials should be collected for application and extension in enterprises to convert them into forces of production as quickly as possible. They will inevitably play an important role in promoting technical progress during the Eighth 5-Year Plan.

The sources of the recommended 100 S&T achievements come from three areas. The first is superior projects which received high-level or state-level awards among

the 2,300-plus S&T achievements made in recent years. The second is new technologies and advanced experiences recommended as effective by production and construction units. The third is projects recommended by departments and bureaus in the China Unified Distribution Coal Mine Corporation.

These technical achievements can be screened according to certain principles. The first is technical maturity, passing technical examination and acceptance, and being confirmed through utilization in practice. The second is broad-ranging projects with a rather wide range of applications. The third is those which require few investments, produce many outputs, and have rather obvious benefits. Based on these principles, we chose 100 new technologies in six areas for extension by the corporation. These include the 20 key extension projects.

People are more familiar with some of these 20 key extension projects, like "mine environment and working conditions monitoring systems," "comprehensive mine dust prevention technologies," "using pressure filters to achieve closed loop circulation of coal slurry," "shaped coal processing and utilization," "optimum product structures and rational coal utilization," and so on. The background situations for five projects have been described in the previous explanations of the attacks on key problems. These are "mineshaft roof bolt support technologies," "coal extraction beneath villages," "hydraulic coal extraction technologies for unstable coal seams," "preventing gas and coal dust explosions and gas eruptions," and "sounding technologies for small geological structures in mines." The only difference is in the level of technical requirements, so these projects will not be described further. Thus, only the remaining eight key extension projects require explanation.

A. New Technologies for Increasing Unit Output of Blast Extraction Faces

This is a suitable technology for use by the corporation in developing multi-level technologies, and it is a technology with a broad range of applications which would have obvious economic benefits after it is extended. It is an effective route for a new technical stage for achieving good safety, low investments, and high output in blast extraction faces. There basically have been no developments over the past 10 years for blast extraction faces in the areas of unit output, efficiency, and equipment. This new technology involves the three matching technologies of microsecond blasting, hydraulic support pillars to prevent blast collapses, and dual-speed or high-power scraper conveyors as well as the corresponding labor organization and management. Since 1987, they have been used at over 20 faces in different geological conditions in three bureaus at Xuzhou, Pingdingshan, and Fengfeng, and increased unit output by an average of 10 to 30 percent. Calculated on the basis of about 1,000 blast extraction faces in coal mines under the China Unified Distribution Coal Mine Corporation, average monthly output at present is about 9,000 tons. At an estimated 15 percent increase in unit output, after basically extending them to all mines within 6 years, it may be possible to increase yearly output for the faces by 10 million tons.

B. New High-Grade Common Extraction Equipment Sets

High-grade common extraction mechanization has developed relatively quickly over the past 10 years. In 1988, the extent of mechanization of high-grade common extraction was 18.19 percent at the 328 high-grade common extraction faces in unified distribution coal mines. However, unit output levels at coal extraction faces has held consistently at the monthly output level of 16,000 to 17,000 tons, a manshift efficiency of 5.7 to 5.8 tons. The main problem is the definite limitations to using coal extractors. An example is small traction force and the inability of single roller tubes to cut their own openings, which means the full height must be divided up for two extractions. To deal with these problems, new high-grade common extraction equipment sets use chainless (or chain) traction dual roller tube coal extractors, dual-speed scraper conveyors, and single hydraulic support pillars. Beginning in August 1988, their utilization at Feicheng Chazhuang Coal Mine produced a monthly output of 45,000 tons, a 40 percent improvement over unit output from high-grade common extraction under similar conditions and a 26.3 percent increase in manshift efficiency. For this reason, extension of these new sets of high-grade common extraction equipment is an effective way to achieve additional increases in unit output and work efficiency. If they can be extended to 150 faces within 6 years, calculations based on a 20 percent increase in unit output give a projected increase of about 5 million tons in face output by 1995.

C. Fully Mechanized Mining Technologies for Thick Coal Seam Roofs and Diamond-Shaped Metallic Grids for Use in Seam-by-Seam Extraction

Thick and extra-thick coal seams account for over 40 percent of output and reserves in China. For this reason, all areas have been very concerned with solving problems of mechanized extraction over the past several years and it has developed very quickly. There are three technical avenues at present. One is employing seam-by-seam extraction, which is an extraction method that has been used historically. Experiments with automatic installation of hydraulic support grids are now under way in Datong, Qincheng, and other bureaus. The second is fully mechanized extraction of the full height in one pass for 3.5 to 4.5-meter-thick coal seams. This is restricted, however, by controlling roofs, coal wall flaking, tunneling and support in large cross-section trough following, and other areas. Extraction of medium hardness coal seams in several locations with good geological conditions is economical and safe. It is being used in China in mines in Xishan, Kailuan, Xingtai, Yima, and other bureaus and Xingtai Bureau has reached a maximum monthly output of more than

120,000 tons, attaining rather good results. Xuzhou and Datong bureaus are now experimentally developing full-height fully mechanized equipment and technologies for extracting 4.5-meter-thick coal seams in a single pass under "three soft" and "three hard" conditions. The third is fully mechanized extraction of roof coal. Experiments and applications are being carried out in mines in Liaoyuan, Yaojie, Pingdingshan, and other bureaus. They are using single conveyors and dual conveyors for two types of roof coal supports with simple systems. There have been substantial increases in unit output, manshift efficiency, and recovery rates and a significant reduction in the amount of tunneling. For this reason, mines in many bureaus are quite enthusiastic about developing fully mechanized extraction of roof coal. Given the present situation in technical developments, they are restricted by roof properties, coal seam hardness, natural combustion periods, and other areas, so we must do experiments and attack key problems in the future. At present they can be extended for use in suitable situations where the roof can be allowed to fall as extraction proceeds, where the coal quality is relatively soft, and where the natural combustion period is rather long. This is particularly true for steeply-inclined extra-thick coal seams and gently-inclined coal seams thicker than 7 meters where rather good technical economic results can be attained.

Diamond-shaped metallic grids can be used for seam-by-seam extraction. According to statistics, seam-by-seam artificial false roof extraction is being used on about 400 faces for coal extraction in unified distribution coal mines. Most are now using a criss-crossed grid as an artificial false roof. Because of its low strength and poor corrosion resistance, it often causes "net dragging," "net wrapping," and even roof leaks when the bottom part of the seam is being extracted, causing great problems for production and safety. The newly developed diamond-shaped metallic grid is stronger. The load-bearing capacity of a single layer diamond-shaped grid made of No 8 wire is 54 percent higher than that of a dual-layer criss-cross grid. Moreover, it has a higher malleability and pressure allowance, stronger self-locking properties, and is easier to handle. It is being used on six fully mechanized extraction, high-grade common extraction, and blast extraction faces in Hebi Bureau with rather obvious benefits. It has provided relatively good solutions to the problems of "net dragging," "net pulling," and roof leaks. It saves 0.5 kilograms of steel per ton of coal under conditions of three-seam extraction of 8-meter-thick coal seams, and it can conserve back-timber and gangue retaining screen material. Costs per ton of coal can be reduced to 0.87 yuan. Thus, we can make a major effort to extend its utilization in three-layer extraction of coal seams.

D. Sets of Equipment for Repairing Single Hydraulic Supports

The China Unified Distribution Coal Mine Corporation has already decided to make a major effort to extend the use of single hydraulic supports and plans to use single hydraulic supports on 1,300 coal extraction faces in China's coal mines. The number of supports registered will be as many as 2 million, and based on a major overhaul schedule for single hydraulic supports which is generally every 2 years, 850,000 to 1 million single hydraulic supports would have to be repaired each year. Thus, we must have the corresponding sets of inspection and repair equipment to meet the needs of production. This inspection and repair equipment is mainly 10 types of special purpose equipment which includes cleaning machines, column bending machines, straightening machines, diffraction grinding machines, testing consoles, and so on, as well as electroplating equipment and zinc phosphate plating technologies which have a full range of functions including column straightening, cleaning, repair, inspection, and so on. Each set of equipment would have a yearly repair capacity of 12,000 to 15,000 single hydraulic supports. At present 36 mining bureaus including Kailuan, Xinwen, Pingdingshan, Hebi, Shizuishan, Fengfeng, Songcao, and others have outfitted and completed inspection and repair centers and an additional 34 inspection and repair centers are expected to be completed and put into operation in the winter of 1989 and spring of 1990.

E. Technical Improvements in Mine Shaft Lifting Systems and Equipment

Problems with inadequate lifting capacity in main shafts exist in many mines where transformation to exploit potential is possible. The main reason is backward technical equipment. BM and KF-type carts and other outdated and mixed brand equipment accounts for 63.6 percent of total stocks and the equipment frequently operates under overload conditions. Tunnel heights are inadequate and braking performance is not good in 112 mines and there are hidden dangers to safety. Lightweight skips, lightweight cages, drop prevention devices, cable winch spring valves, and electrical protection systems have raised the lifting capacity by 10 to 20 percent, increased safety, and created conditions for exploiting potential in old mines. They should be extended in large numbers in transformation of old mines and new mine construction.

F. Mine Leakage Communications Systems

Radio communications is a means of communications between circulating personnel and circulating machinery and equipment. When radio waves are transmitted in mines, however, absorption of the radio waves by the rock of tunnels prevents the transmission distance from meeting requirements. As a result, there has never been an effective solution for communications tools between circulating personnel and haulage locomotives. Over the past few years, foreign countries have developed a type of leakage communications system which lays a special types of leakage cable to "transmit" radio waves and serve as a communications channel, with very good results. China did not have this kind of leakage cable in the past and had to buy coaxial cable as a substitute. The cost was as high as 40 to 50 yuan per meter, so there was

no way it could be extended. Fushun Branch of the Coal Sciences Academy developed a leakage cable and complete leakage communications system for use in mines which cost just over 4 yuan per meter, and it has undergone industrial testing in three shafts at Fanluozhuang Mine. The voice transmission quality and volume were both better than the induction telephones and overhead line locomotive carrier wave telephones formerly used in mines, enabling a grid coverage range of up to 10 kilometers through the use of radio leakage communications. Moreover, it can be linked to mine production dispatching communications systems, which provides a rather good solution to the problem of communications in mines for circulating communications and overhead line locomotives. We are preparing to produce them in large quantities in 1989 and expect to extend 10 sets in 1990. They can be gradually extended and utilized first in large and medium-sized mines.

G. Comprehensive Fire Prevention Technologies for Mines

Conditions in this area have been described to some extent in the previous section of projects to attack key problems, so I will only discuss combustion resistant cables and rubber belts. Common rubber cables and rubber conveyor belts are a major cause of mine fires. They often cause large fires because of their easy combustibility and delayed combustibility. Statistics from foreign countries show that fire accidents caused by common rubber conveyor belts account for about one-fifth of all mine fires. During the 13-year period from 1975 to 1988, there were 18 conveyor belt fires in unified distribution mines. Ignition of a cable in Xinmi Bureau in 1976 ignited coal walls and conveyor belts. A delayed combustion accident with a conveyor belt occurred in the Wudasan Mine in 1981 and forced a closing of the mine. It could not be opened for several years, and the set of fully mechanized mining machinery was destroyed, causing enormous economic losses. After adopting combustion resistant conveyor belts, England, Czechoslovakia, and other nations basically eliminated this type of disaster. Only 500,000-plus meters of the 6.5 million meters of conveyor belts now in operation in China's mines are combustion resistant conveyor belts. To prevent accidental combustion of cables and conveyor belts, we should continue to extend and utilize combustion resistant cables, and we should replace all the cables in underground mining regions by the end of the Eighth 5-Year Plan. At the same time, we should give preference to using combustion resistant shielded rubber-jacketed cables in mines and continue to extend and utilize combustion resistant conveyor belts. Moreover, we should also gradually extend high-strength combustion resistant conveyor belts. It deserves special mention here that the combustion resistant cables and combustion resistant conveyor belts we extend should conform to China's national standards and the Shanghai Branch of the Coal Sciences Academy should inspect the products to assure that they meet specifications. Fire accidents caused by friction in conveyor belts occurred in three mines in Japan during 1984 and killed 83 people. The reason was that the combustion resistance standards of their so-called combustion resistant conveyor belts were too low. There are now 18 plants in China which produce combustion resistant conveyor belts, and we should strengthen quality supervision and inspection. All bureaus and mines also should pay attention to whether or not these products conform to state standards when they are making purchases and whether or not they have an inspection of specifications certificate from the coal system.

H. Two Segment Gasification Technologies in Mining Regions

Mining region coal gasification is a problem which urgently demands solution. Still, large-scale pressurized gasification technologies like the Lurgi method in Federal Germany are technologically complex and involve substantial costs. Manufacturing gas in coking furnaces is only suitable for use in regions which have coke resources, and the required investments are also substantial. Poland, France, Italy, and other countries have widely adopted two-segment furnaces for water and coal gas and these are better suited to China's conditions. The technology is simple and it can be done at normal pressure without using oxygen. The suitability of coal varieties is relatively broad, ranging from old lignite to long-flame coal, weakly cohesive coal, non-cohesive coal, gas coal, poor coal, and lean coal, all of which can be used. For this reason, the Coal Sciences Academy Beijing Coal Chemistry Institute has developed a new method for making coal gas suitable for extension and utilization in China's mining regions and small towns and cities that has filled in a blank space. This new method is characterized by the retention of the water and coal gas two-segment furnace described previously and is integrated with China's actual conditions of the adoption of large numbers of water and coal gas furnaces. Its advantages are simple equipment and technologies, limited costs, and a rather small furnace size. An example is the 1.6 meter diameter water and coal gas two-segment furnace successfully tested in the Xinwen Mining Bureau. The normal gas manufacturing capacity for a single furnace is more than 600 Nm^3/hour and the caloric value of the coal gas is generally 2,500 kcal/Nm^3, so the results are rather good and it can be extended and utilized. At the same time, the next step is to develop a slightly larger furnace such as a 2.26 meter diameter water and coal gas two-segment furnace suitable for use in mining regions with somewhat larger populations.

The 100 extension projects recommended by the China Unified Distribution Coal Mine Corporation are merely projects which have been rather important in recent years, have a relatively broad adaptability, and provide rather good results. After discussing them and making determinations, we should: 1) Compile a volume containing the concrete technical content, suitable conditions, and primary benefits for the 100 extension projects; 2) concentrate on the 20 key projects; and 3) concentrate on a few sites for integrated extension to

foster comprehensive benefits. In particular, we should integrate with modernized coal mine construction and use integrated extension of new technologies in conjunction with necessary attacks on key problems to establish several high standard modernized mines.

All regions and bureaus can propose their own extension programs on the basis of the 100 extension projects in conjunction with situations and achievements in their own regions and units, focus on work to extend new technologies, and promote technical progress in their own regions and units.

IV. On Policies and Measures

It is difficult to implement a program to its conclusion without implementing supporting policies and measures. The six policies and measures set forth in the plan program fall mainly in two areas. One concerns increased S&T inputs, such as Articles 2 and 4. The second concerns increased reliance in enterprises on the pressure, motive force, and strength of technical progress, such as Articles 1 and 3. Of course, part of solving problems of policies and measures is an issue which the corporation itself can determine, and it concerns state policies, so we must strive to attain them. For this reason, the articles written here can mainly be determined by the corporation and it can be done now. Only portions of the content of a few of the articles refer to policies which we will strive to obtain, which means that we feel that these policies should be adopted and we hope that the state can support them. An example is the content of the second paragraph in Article 3. To support technical progress, in the past the State Council and Ministry of Coal Industry formulated several policies such as State Council Directive 21 (1985) "Certain Provisional Decisions on Promoting Technical Progress in Enterprises," Ministry of Coal Industry Coal Technology Document No 886 (1985) "Provisional Decisions of the Ministry of Coal Industry Concerning Certain Policies To Promote Technical Progress in Enterprises," and so on. Some of the articles here repeat several articles in these documents, such as the first paragraph of Article 3, and so on. A concrete explanation of the articles is given below.

Article 1. Make Reliance on Technical Progress a Major Aspect of Overall Contractual Responsibility in the Eighth 5-Year Plan

Linking technical progress with overall contractual responsibility can increase the pressure and motive force for technical progress. This is clearly stated in the Ministry of Coal Industry's Document No 886 mentioned previously. The only thing is that some new contents have been added as demanded by practice and plans over the past few years. Examples include the incidence of pneumoconiosis, coal resource recovery rates, completion rates for renewal and transformation of electromechanical equipment, completion rates for projects to attack key S&T topics and extension projects, employee training, and so on.

Article 2. Establish a Stable Coal S&T Development Fund

This article is designed to increase S&T inputs. To solve certain common S&T problems in S&T progress throughout the industry at the present time, the corporation has prepared to begin in 1990 to set aside 0.1 yuan per ton of coal each year for a S&T development fund. Because administrative funds are limited, they certainly should be utilized in a concentrated way to solve key problems. Thus, these funds are under unified control by the corporation and are to be used mainly for major S&T projects to attack key problems. The project funds, equipment purchase funds, and normal labor funds involved in projects to attack key problems should continue to be provided through the corresponding project and production and capital construction channels.

At present, the state has approved 10 enterprises in the coal system for expanded trial points to implement the deduction of 1 percent of their marketing volume in their costs for a new technology development fund. This will be very helpful in promoting technical development and technical transformation in enterprises. These 10 enterprises should certainly draw on these technical development funds and use them well by truly using them to promote technical progress in enterprises. At the same time, we should strive to further expand the trial points.

Article 3. Increase Enterprise Strengths by Relying on Technical Progress

This is divided into two parts. Part one concerns the issue of existing construction units, production enterprises, and geology units setting aside technical development funds, all of which is a repetition of the related articles in Ministry of Coal Industry Document No 886 (1985), so there is no need to explain them further here. The second part concerns policies which we hope the state will provide. The first policy concerns loans for developing mechanization and improving safety technologies in coal mines. We hope that banks will provide them interest-free or at low interest. Another policy concerns our hope that the state will agree to the inclusion of coal mined under difficult conditions within unified distribution and implement the method of negotiated prices for guaranteed quantities. We feel that although coal mined under difficult conditions is generally excluded from the balance sheet or classified as non-economical extractable reserves, extraction of this coal would require substantial inputs, so sales at negotiated prices would be reasonable.

Article 4. Strengthen Construction of Scientific Research and Experiment Facilities

At the 1983 Coal S&T Conference, it was specified that 1 percent of capital construction investments for coal and the necessary foreign exchange would be used to support capital construction for coal science research. Things were basically implemented according to this spirit during the Sixth and Seventh 5-Year Plans with

good results. At present, management of capital construction investments has been changed from allocation to loans, so it is even more necessary that capital construction investments and the necessary foreign exchange be maintained and not fall below existing levels in the Seventh 5-Year Plan to be used to reinforce construction of scientific research and experiment facilities.

Since quality supervision is an important way to promote quality improvements and increase economic benefits, we should emphasize in this article that construction of experimental facilities should be concerned with perfecting and improving existing national-level and ministry-level product quality supervision and inspection centers and specify that policies for grade increases at enterprises, upgrades in product quality, and examination and acceptance of new products should be linked with quality inspection to make it an important pressure and motive force for promoting technical progress and quality improvements in enterprises.

Article 5. Increase Investments in Knowledge, Attract Skilled People, Improve the Quality of Employees, Stabilize Employee Staffs

As for the question of encouraging students to apply to coal academies and schools and providing larger scholarships for students in coal specializations, these have actually already been implemented. As for the question of providing preferential wage treatment for S&T personnel working in the coal industry, on the one hand this should be advocated, and on the other hand we should continue to solve the problem as the coal industry develops and economic conditions in coal mines improve. Regarding the employee system, reforms in the employee system over the past few years have played an important role in protecting labor power and increasing labor productivity. However, to aid technical progress, we should emphasize here that in key job categories like large drivers and maintenance personnel for large-scale electromechanical equipment and excavation machinery, we should be concerned with stabilizing staffs and providing technical training.

Article 6. Have Good International S&T Cooperation and Exchanges

This is an indispensable way to develop coal science and technology. China has now established international cooperation and exchanges with many primary coal producing nations with good results. The emphasis here is on establishing long-term and stable cooperation and exchanges to enable us to rapidly acquire new foreign technologies. At the same time, we should choose superior comrades directly involved in S&T work and send them to participate in work in this area to attain our desired goals.

Appendices to the corporation's 6-year S&T development plan program contain 50 projects to attack key problems and 100 extension projects. This is only a discussion draft, and we ask that delegates discuss and revise it and strive to use our efforts during the Eighth 5-Year Plan to solve many major scientific and technical problems in production and construction and establish modernized mines at 1980's levels, make rather obvious changes in the technical situation in coal mines, and make new contributions to sustained, stable, and healthy development of the coal industry.

Developing Science and Technology for the Coal Industry

906B0048A Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese No 1, 25 Jan 90 pp 2-6

[Article by MEITAN KEXUE JISHU Editorial Department: "Fight for Scientific and Technical Progress in the Coal Industry"]

[Text] We are now facing the final year of the Seventh 5-Year Plan in our administrative rectification and intensive reform. MEITAN KEXUE JISHU salutes its readers and would like to express its wishes for their new contributions to S&T progress in the coal industry during the new year.

From 3 to 12 November 1989, the China Unified Distribution Coal Mine Corporation convened the Coal Industry S&T Work Conference to summarize and exchange experiences in relying on S&T progress to develop the coal industry in recent years. The conference studied the Coal Industry S&T Development Program for the Eighth 5-Year Plan and projects for short-term attacks on key problems and extension. It commended superior S&T achievements and projects as well as units which relied on S&T progress to attain obvious benefits during the Seventh 5-Year Plan, and it made deployments for future S&T work in the corporation. The conference results show once again that reliance on S&T progress is an essential route for developing the coal industry.

I. We Must Increase Our Understanding of Reliance on S&T Progress by Raising It to Strategic Heights for Developing the Coal Industry

After the 3d Plenum of the 11th CPC Central Committee, China formulated a strategic deployment which divided economic construction into three steps to basically achieve modernization during the middle part of the 21st century. The first step has basically been achieved and we are now working on the second step. This is the key step. Achievement of the strategic goals of the second step requires energy resource guarantees. We can be sure that coal's domination of the configuration of our energy resource production and consumption structure will not change for a rather long time into the future. Projections by many energy resource research units in China and foreign countries indicate that demand for primary energy resources in China by the year 2000 will at least surpass 1.4 billion tons of raw coal. The coal industry is certainly an important pillar in

China's national economy and a major player in achieving our second strategic goal in economic construction.

The coal industry has experienced enormous growth since the 3d Plenum of the 11th CPC Central Committee and obvious changes have occurred in production technologies. Coal output has grown in a sustained and stable fashion. Raw coal output in China surpassed the major milepost of 1 billion tons in 1989. Gratifying achievements have been made in capital construction, many shaft (and strip) mines have been completed and gone into production, and there has been a noticeable shortening of mine construction schedules. There has been a significant increase in the degree of mechanized excavation. The degree of excavation in China's unified distribution coal mines reached 58.02 percent in 1988, including a fully mechanized mining extent of 31.36 percent. The degree of mechanization in tunneling and loading reached 55.53 percent in 1988. There have been stable increases in full staff productivity, which surpassed 1 ton/manshift in 1986, ending a situation of fluctuation at about the same level for many years. It reached 1.092 tons/manshift in 1988. There have been additional improvements in production safety with the best historical levels being attained for 4 consecutive years. Several modernized bureaus and mines have been established. We completed four modernized mining bureaus and 32 modernized mines at Luo'an, Qincheng, Yanzhou, and Xingtai. There have been substantial improvements in strengths and levels in coal S&T. Ten experimental systems for extraction, tunneling, haulage, support, and other areas have been built in the "Coal Mine Excavation Experiment Center" over the past several years, and we have built and transformed 24 laboratories, attaining advanced levels in foreign countries or in China. The "Coal Mine Safety Experiment Center" and "Coal Dressing Experiment Center" have completed several experimental measures at substantial levels. We also have completed six national-level and three ministry-level product quality supervision and inspection experiment centers, and completed several laboratories of the scientific leading edge and technical reserve nature for increasing the value of coal through intensive processing. S&T staffs have been strengthened and the quality of S&T has been improved. There are over 300,000 technical personnel of all categories in the coal system, including over 90,000 people who have attained mid-level and advanced technical and professional job qualifications. A specialized staff with a rather strong capacity to attack key problems has been formed in specialized coal science research academies, and they have taken on a large portion of attacks on key topics for the state and ministry. Almost 90 local and enterprise research organs are working vigorously on the first line of production and there have been substantial developments in scientific research forces in institutions of higher education. Reforms in the coal S&T system have developed intensively and there is closer integration of scientific research with production. Reforms in the allocation system for scientific research related to coal have been implemented for 4 years now and they have promoted greater voluntary integration of scientific research with production and construction. We are beginning to take the road of integrating research, development, and administration. Research units have implemented a separation of party control and government administration, a responsibility system for academy directors, all types of contractual responsibility systems, and technical and professional recruiting systems. Implementation of experiments in reform of the allocation system, optimization of labor organization, and other experiments have improved internal operational, managerial, and administrative mechanisms and increased vitality. There is growing horizontal integration of scientific research, design, manufacturing, production, and other units, and technology markets are continually developing, creating a new situation in integration between S&T and the economy. Basic work in management of coal technology has been strengthened and there have been new improvements in product quality. A total of 165 state and ministry standards have been formulated and 23 standards have been revised since 1985; 56 products have received state superior quality product designations; 27 enterprises have been classified as state second-level enterprises; and 35 groups have been named state superior quality management groups on 52 occasions. Several major achievements have been made in scientific research work and they are being extended and applied in production and construction. A total of over 1,300 achievements have been made on coal battlelines since 1985, including 63 which received state S&T progress awards and 343 which received ministry-level S&T progress awards. An additional seven items received state invention awards. All these show that major achievements have been made in the coal industry and coal S&T.

We should note, however, that the coal industry faces a serious situation that is both an opportunity and a challenge, and we must conscientiously deal with it. On the one hand, there has been a comprehensive coal shortage since 1988. Forecasts indicate that even with output reaching 1.4 billion tons in the year 2000, there will still be a substantial shortage. Moreover, to produce 1.4 billion tons, output will have to rise by an average of 40 million tons each year over the next 10 years. This will be quite difficult, both for unified distribution coal mines and for local coal mines. Insufficient inputs since the Seventh 5-Year Plan have led to a declining capacity for coal development, and we have a severe lack of a capacity for self-transformation and self-development and declining production reserves. In the absence of special measures, it will be hard to continue to achieve sustained and stable growth in output. For this reason, output pressures will continue to be a prominent contradiction facing the coal industry for quite some time into the future. On the other hand, arduous tasks are involved in transforming the situation of backward technology in the coal industry. Although there have been substantial improvements in the coal production technology situation and S&T levels, we still lag far behind, both in

comparison to the world's main coal producing nations and to other industries in China. The degree of mechanization in coal extraction in the world's main coal producing nations like the Soviet Union, the United States, Federal Germany, England, Poland, and so on is almost 100 percent, and the degree of mechanization in fully mechanized extraction is more than 90 percent in most of them. China, however, lags far behind in comparison. Labor productivity in our unified distribution coal mines is just one-half that in the Soviet Union and France and one-third that in Federal Germany, Poland, England, and Japan. We also lag substantially behind them in the area of safety. Based on a comparison of statistics for technical progress in independent accounting enterprises under ownership by the whole people from 1953 to 1984, the annual rate of technical progress in each primary industrial sector was: machinery 4.68 percent, electric power 3.2 percent, petroleum 2.54 percent, chemical industry 1.18 percent, and metallurgy 1.05 percent. It was only 0.78 percent for coal, however. The coal industry's situation of excessive numbers of employees, low efficiency, and poor safety awaits further improvements. Otherwise it will seriously affect and restrict development of the coal industry.

How can the coal industry get out of this predicament? Besides the need to increase inputs and intensify reforms, the most important thing is to achieve a real shift of coal development onto the track of relying on technical progress. Accelerating S&T progress in the coal industry, speeding up the pace of modernized mine construction, and striving to develop mechanization are the trends of the times and made urgent by circumstances.

According to one understanding, the coal industry could still produce whether or not it focuses on S&T and it is even felt that the coal industry is just resources and labor power. This type of understanding is an extremely great obstacle to S&T progress in the coal industry and must be firmly overcome. The historical development of the coal industry itself has shown that without progress in coal S&T over the past 40 years, it would have been impossible to achieve a yearly output of 1 billion tons of raw coal. Practice also has proven that by relying solidly on S&T progress, enterprises can achieve substantial development and results will be greatly increased. Practice in relying on S&T progress in many large bureaus and mines such as Qincheng, Luo'an, Yanzhou, Xingtai, Pingdingshan, Qitai He, and others fully confirms this point. We are now in an era of surging S&T development and the tidal wave of the new technological revolution is moving ahead at a tremendous speed. Permeation of industry by S&T and reliance of industry on S&T are more powerful than at any other time. One's attitude toward reliance on technical progress is in reality a yardstick by which the consciousness of every comrade and especially leading cadres can be evaluated. We certainly must have a powerful sense of mission and urgency, rely on S&T progress, and invigorate the coal industry.

II. There Must Be Comprehensive Planning and Focused Attacks on Key Problems To Raise Progress in Coal S&T to a New Level

This is the final year of the Seventh 5-Year Plan. To provide clear goals, requirements, and deployments for coal S&T progress, we should begin making plans now for S&T work for the entire Eighth 5-Year Plan, formulate focuses for attacks on key problems, and actively organize implementation.

The overall goals for developing coal S&T work are to achieve a greater orientation toward coal production and construction, work closely around development deployments for the "three main aspects" and strategic deployments for the "three primary matters," concentrate forces to solve key technical problems in mechanization of excavation and haulage, coal mine safety, and coal processing and utilization that have significant economic and social benefits; develop multi-level technologies, focus on applied research and technical reserves, actively extend new broad-based technologies with high benefits, widely undertake mass-type technical innovation activities, and strive to attain technical economics benefits; strengthen technical management, implement production centralization, develop coal mine mechanization and modernization, increase unit output and unit tunneling, strive to improve the coal mine production safety situation, and fight to attain the projected goals set for 1995 in the area of full staff productivity and safety.

Based on these overall requirements, we should actively and effectively solve urgent and key technical problems in the areas of coal production, construction, processing and utilization. We should strive to basically enable the establishment of primary technical equipment on domestic production and attain world levels of the early or mid-1980's in technical performance, product variety systemization, product quality and reliability, and excavation machinery and safety equipment to achieve a rather noticeable improvement in the technical economics situation. We should make substantial improvements in the coal mine safety situation and enable basic control of the occurrence of major vicious accidents. For this reason, we also should improve overall capabilities in scientific research, especially in the need to stabilize and train scientific research staffs which attain world levels. We should establish rather complete intermediate testing and testing measures, strengthen scientific research reserves, and maintain stable capital channels.

To achieve these overall goals and requirements, we should work hard at key tasks, which are:

1. Improve coal extraction technologies, develop multi-level mechanized coal mining technologies. First, we should manage existing coal extraction equipment, raise its utilization rate, solve problems with rational matchups for systems and auxiliary facilities, provide sounding measures for small geological structures in mines, improve coal extraction technologies, and implement rational concentration of production in mines. Second, we should make further improvements in the

reliability of broad-based coal extraction equipment and mining region systems, and increase the machine operation time by 20 percent above existing foundations. Third, we should develop high-power high-efficiency fully mechanized excavation equipment, and achieve 10,000 ton daily output and 2 million ton yearly output level faces. Fourth, we should make a major effort to extend new three-item matching technologies for high-grade common extraction and blast extraction. Extend fully mechanized extraction technologies for mining thick coal seams in suitable regions, gradually extend hydraulic extraction technologies in unstable coal seams, and digest and study large-scale open-pit mining technologies.

2. Accelerate the pace of new mine construction. We should perfect and improve common mechanized shaft boring technologies in vertical shafts, reinforce research on geological sounding and control of rock in strata surrounding tunnels, strive to drill "dry shafts," improve construction organization and management, raise shaft boring technologies to the level of completing 35 to 40 meters of shafts each month, and attack key technical problems to reach the 50- to 60-meter level. We should continue to work on complete technologies for mechanized excavation of coal and half coal-half rock and improve their reliability and matchup to attain a yearly tunneling level of 4,000 to 5,000 meters. We should improve the reliability of blast method mechanized work lines for rock tunnel boring and increase the degree of domestic production for equipment and components, and attain a yearly tunneling level of 1,000 meters. In hidden shafts, in-shaft coal bunkers, and extended depth shaft construction, make a major effort to extend back-shaft drilling rigs which have a rapid shaft completing speed and are safe to operate. At the same time, we should reinforce geological prospecting reserve strengths, extend comprehensive prospecting methods which integrate exploratory drilling, seismic testing, well logging, and so on, extend new technologies to liberate coal resources in old mining regions of east China which pose water dangers, accelerate the pace of prospecting, and provide sufficient reserves to assure the scale of newly built mines.

3. Do good work in comprehensive transformation of mine lifting and haulage systems. We should adapt to local conditions in extending 3-ton mine hopper cars and adopt large-capacity rubber belt conveyors, select large capacity coal bunkers, extend lightweight skips, and utilize microelectronics to transform lifting systems in large shafts and mining regions with suitable conditions. We should study and solve problems with underground auxiliary haulage systems, and in particular we need to deal with high efficiency auxiliary haulage equipment matched up with fully mechanized mining and mechanical tunneling to provide new technical facilities for faster moves of fully mechanized mining equipment and mechanization of fully mechanized mining face haulage.

4. Achieve a basic grasp of technologies for controlling major vicious accidents. We should use a variety of technical means in a major effort to study gas eruption prediction and forecasting technologies; extend high efficiency fans and high efficiency exhaust drilling machines and technical equipment, increase the exhaust amount and exhaust rate, and establish coal tunnel tunneling ventilation and safety protection systems; study and solve natural combustion prevention technologies for thick coal seams and steeply dipping coal seams and control fire sources, extend combustion resistant rubber belts and combustion resistant electrical cables, extend beam tube monitoring systems and other new fire prediction and forecasting technologies; extend and perfect water trough, water pouch and moisture-proof explosion prevention and isolation measures; and gradually establish and perfect safety monitoring systems. We also should deal with problems of full mechanization of ultra-thin liberated seam extraction and perfect complete dust control technologies in China's coal mines, and we especially should solve problems of preventing respiratory dust.

5. Develop coal processing and utilization technologies. We should develop and extend several types of new high benefit, high efficiency washing equipment and gradually solve problems with closed-loop coal slurry circulation and increase the reliability of large-scale coal dressing equipment. We should conduct research and experiments on quality improvement processing of young coal and joint coal-oil refining technologies. Integrate with engineering projects to develop research on coal-water mixture preparation, pipeline transmission, and combustion technologies. Develop coal gasification technologies in mining regions and do research on coal desulfurization and on mine water treatment technologies and conversion to resources. Further develop gangue power plants and comprehensive utilization technologies for cement construction materials and low heat value fuels.

6. Improve coal machinery product manufacturing technologies. We should strengthen development of large capacity coal conveyors, high power excavation machinery, high strength support equipment, high voltage mine electrical equipment, large flow rate pumps and valves, auxiliary haulage and post-tunneling matchup, and other areas, solve problems with key technical equipment, and do good work in technical transformation in coal machinery plants, to do good basic work for increasing product reliability and adaptability.

III. Truly Implement S&T Progress Everywhere

1. Conscientiously and earnestly implement CPC principles and policies for S&T work. We must conscientiously and earnestly implement party lines, principles, and policies since the 3d Plenum of the 11th CPC Central Committee, adhere to the four basic principles, adhere to reform and opening up, and earnestly develop the struggle against bourgeois liberalization. We should resolutely adhere to and implement Comrade Deng Xiaoping's views that S&T are forces of production, that

S&T personnel are part of the working class, and other principles of Marxism. We should conscientiously and resolutely adhere to the strategic principle determined by the CPC Central Committee and State Council that "economic construction must rely on S&T and S&T must be oriented toward economic construction." We should give full play to the advantages of the socialist system and develop all types of coal S&T activities through comprehensive planning and arrangements which take all aspects into consideration, make key breakthroughs, and strive for coordination through the establishment of goals in a step-by-step and organized manner. We should foster the spirit of independent decisionmaking, self-reliance, and hard work and attack key technical problems according to the principle of relying mainly on our own efforts supplemented by fighting for foreign aid. We should truly strengthen party leadership over S&T work, adhere to the socialist orientation in S&T work, continually raise the political consciousness and ideological morality levels of S&T personnel, establish excellent employee morality and enterprise spirit, strive to initiate discussing ideals, observing discipline, and comparing contributions, and greatly foster a spirit of bold study, innovation, and valiant devotion.

2. On the basis of relying on S&T progress, perfect and develop enterprise contractual responsibility management systems and ensure technical progress in enterprises. Enterprises are an integration of S&T with the economy. Intensive reforms of the economic system should proceed concurrently with reinforced reliance on technical progress. We should use the suggestion that "enterprise contractual responsibility contracts should include S&T progress requirements" proposed by the State Council in its "Main Points for Reform of the Economic System in 1989" as a foundation in conjunction with the characteristics of the coal industry to study and formulate S&T progress indices that should be included in contractual responsibility systems for enterprise management, and we should combine examination of the completion of overall contractual responsibility in enterprises and the goals of the responsibility system for the terms of office of bureau and mine (plant) managers with strict examination and reward and punishments according to their completion of technical progress indices. We should announce the technical progress situation in all enterprises according to a specific schedule, propagandize and commend personnel who have performed meritorious service, and select pioneers in technical innovation.

3. Strengthen S&T inputs, strive to reinforce the capacity of enterprises to absorb and develop technologies. Increased inputs are the main issue in dealing with inadequate technical reserve strengths. We must make a firm decision to increase inputs in S&T, devise ways to expand channels for administrative funds, and assure that there is a relatively stable source of capital. Administrative departments should concentrate on providing a specific amount of special S&T development funds to be used for attacks on key problems and extension in major industry projects and basic research on strategic technologies to ensure implementation of the Eighth 5-Year Plan. They also should continue to reinforce construction and innovation of key experimental and testing measures. Major S&T research tasks which must be solved during development of new regions and construction of new mines (plants) can be dealt with using capital construction channels. As policies permit, enterprises should try to increase their inputs in technical progress, and S&T development capital in existing channels must certainly be truly used to promote technical progress in enterprises. At the same time, we should think of every possible way to open channels, increase S&T inputs, achieve value of output and benefits from technical progress, and form benevolent cycles through mutual complementarity of production and technical progress.

4. Further intensify reforms in the S&T system, integrate S&T more closely with production and construction. Specialized research academies should orient toward production and construction to form technical development centers for the industry. We should correctly handle the relationship between the present and the long term and between technical services and technical reserves. We should orient toward open research and experiment measures for the entire industry. Specialized research academies should become new technology R&D centers, quality supervision and inspection centers, standard and measurement research and formulation centers, and technical service centers for the entire industry. We should take advantage of the multidisciplinary qualities, highly comprehensive nature, solid foundations, and concentration of talented people in institutions of higher education to enable institutions of higher education to play a role in basic and theoretical research on applying new technologies and making breakthroughs in leading disciplines by becoming education centers and research centers. We should strengthen the capacity of enterprises for absorbing and developing technologies. Large and medium-sized enterprises should further establish and perfect their own S&T development organs to reinforce absorption, digestion, extension, and application of new technical achievements, and promote technical renewal and technical transformation in their own enterprises. We should further implement multidirectional horizontal integration and promote integration of S&T and the economy. Encourage and support S&T organs to rely on new technical achievements, integrate with enterprises, and form vanguard enterprises and enterprise groups for scientific research. We should strive to open up and develop technology markets and reinforce technical consulting, technical training, technical services, technology transfers, and other work.

5. Strengthen technology management work, provide a solid foundation for coal S&T progress. We should conscientiously implement a senior engineer responsibility system at all levels, establish and perfect a technology management system headed by senior engineers, and provide full guarantees for the duties and limits of

the authority of senior engineers. We should strictly implement the "Technology Policy for the Coal Industry" and "Certain Stipulations on Basic Work in Coal Mine Production and Technology Management," overcome deviations of softness, laxity, and broadness in technical work at present, and strengthen inspection and examination of the situation in implementing the "Technology Policy" and "Certain Stipulations." Further reinforce quality management, technical supervision, and inspection work. We should continue to implement mining face engineering quality standardization, mineshaft maintenance and track emplacement quality standardization, safety and ventilation quality standardization, and coal quality standardization formulated by the former Ministry of Coal Industry, do good work in coal mine geological prospecting work and reserves management, and do good work in environmental protection according to state stipulations in the "Environmental Protection Law." We should further perfect and strengthen technology inspection centers, do good product quality supervision, and reinforce standardization and measurement work.

6. Strengthen coal S&T staff construction, comprehensively improve the quality of coal employee staffs. In the final analysis, S&T progress depends on talented people and staff quality. For this reason, we should place personnel and staff construction in an extremely high status and focus on them. We should further motivate the initiative of S&T personnel, truly respect the talents of personnel, respect knowledge, and enable S&T personnel to make full use of their skills and abilities in technical progress. We should induce S&T personnel to establish a proletarian world outlook and methods, wholeheartedly rely on the working class, and resolutely adhere to correct political orientations. We should focus on selecting and using personnel with superior skills, strengthen training and education work for young S&T personnel, show concern for and resolve real problems of S&T personnel in work and life, and strengthen continuing engineering education for S&T personnel. We should take full advantage of the capabilities of coal academies and schools in training personnel, solidify intensive growth, readjust the structure of specializations, and accelerate personnel training in areas where we have shortages. We should begin with comprehensive improvements in the scientific and cultural qualities of employee staffs, and strive to reinforce and perfect cadre and employee training work.

The 5th Plenum of the 13th CPC Central Committee passed a decision on further administrative rectification and intensified reform, and formulated the principle of adhering to long-term sustained, stable, and coordinated development of the national economy. We should resolutely adhere to the spirit of the 5th Plenum of the 13th CPC Central Committee, conscientiously implement the policies of administrative rectification and intensified reform, inspire spirit, work hard, and struggle tenaciously for technical progress in the coal industry.

Future Coal Combustion, Sulfur Removal Technologies Under Study

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[Article by Yang Tianzheng [2799 1131 2973], Ma Chi [7456 7459], Xu Yingjiu [1776 5391 0046], Yang Qiwen [2799 0796 2429], and Li Zhihua [2621 2784 5478]: "Optimal Choices and Forecasts for Coal Combustion and Desulfurization Technologies in China". This article was extracted by Comrade Li Jianye [2621 1696 2814] from "Development Strategies and Policies for New Coal Utilization Technologies in China" (stage research report).]

[Text] **Abstract**

This article introduces surveys and forecast stage research achievements on adoption of the Delphi method for new coal utilization technologies by the State Science and Technology Commission's Industrial S&T Department and the Science and Technology Promotion R&D Center. It forecasts developments in coal combustion technologies, coal-fired combined cycle power generation technologies, coal desulfurization technologies, and other areas. It also assesses R&D implementation time frames, technical characteristics, and R&D possibilities for reference by the state in formulating plans to develop new technologies for coal utilization in the Eighth and Ninth 5-Year Plans.

Key words: coal, combustion technologies, desulfurization technologies

The State Science and Technology Commission's Industrial S&T Department and the Science and Technology Promotion R&D Center made surveys and forecasts concerning adoption of the Delphi method for new coal utilization technologies with the goal of studying and formulating development strategies and policies for new high efficiency and clean coal utilization technologies based on China's concrete technical economics and social conditions. The forecast period covers 1990 to 2000. Research reports during this stage include coal combustion, coal-fired combined cycle power generation, desulfurization technologies for use during coal combustion, and flue gas desulfurization technologies. They recruited 23 experts with rich experience and intellectual levels from all over China and made significant achievements after two rounds of consultation. The technical forecast is the foundation for policy formulation and can serve as a reference for selecting key development realms and investment directions. This forecast will provide an important foundation for the state in formulating new coal utilization technology plans in the Eighth and Ninth 5-Year Plans. The optimal technology selections in this stage of the research have two parts. Part one concerns coal combustion technologies, including atmospheric and pressurized fluidized

bed combustion, atmospheric and pressurized circulating fluidized bed combustion, and coal-fired combined cycle power generation. The second part concerns technologies for desulfurization during combustion and flue gas desulfurization. The content of the forecast includes implementation time frames and scales, efficiency, environmental protection characteristics, extent of large-scale development, economics, R&D systems, and so on.

This article outlines achievements in forecasting choices in this stage.

I. Coal Combustion Technologies

1. Fluidized Bed Combustion Technologies

Fluidized bed combustion technology	Order of selection	Voting rate (percent)
Atmospheric fluidized bed combustion (AFBC)	1	95.2
Pressurized fluidized bed combustion (PFBC)	2	76.2

The reason for the selection is that AFBC technologies are relatively mature. When electric power departments adopt AFBC technologies to renovate equipment, they can control SO_x and NO_x discharges and increase their power generation capacity.

2. Atmospheric Fluidized Bed Combustion Technologies

Atmospheric fluidized bed combustion technology	Order of selection	Voting rate (percent)
Atmospheric circulating fluidized bed combustion	1	85.7
Combined bubbling bed-circulating fluidized bed combustion	2	81.0
Atmospheric bubbling bed combustion	3	71.4
Medium fluidized bed combustion	4	33.3

The reasons for the selection are high combustion efficiency, good environmental protection characteristics, ease of increasing scale, and good adaptability to a variety of coal types.

3. Typical Atmospheric Fluidized Bed Combustion Technologies Used in Foreign Countries

Atmospheric fluidized bed combustion technologies used in foreign countries	Order of selection	Voting rate (percent)
Federal Republic of Germany's (Bobaige) Corporation Circofluid circulating bed	1	76.2
Finland's (Aosilong) Corporation Pyroflow circulating bed	2	66.7
Federal Republic of Germany's Lurgi circulating bed	3	52.4
United States' Battele Laboratory multi-solid circulating fluidized bed	4	38.1
United States' (Fusite Huile) Corporation FWFBC circulating bed	5	28.6

Many countries are working on R&D for circulating fluidized bed combustion technologies. Although they are not yet mature, breakthrough advances have been made, each with their own differences. Combined bubbling bed-circulating fluidized bed combustion technologies hold first place due to their high combustion efficiency, high desulfurization rate, more rational flow process, and more mature technology. China has a definite technical foundation, the equipment is not too complex, manufacturing costs are less inexpensive, increasing scale is easy, and so on.

4. Pressurized Fluidized Bed Combustion Technologies

Pressurized fluidized bed combustion technologies	Order of selection	Voting rate (percent)
Pressurized circulating fluidized bed combustion	1	75.0
Pressurized bubbling bed combustion	2	50.0
Simultaneous development of both of the above technologies	3	30.0

The reasons are the same as those for atmospheric beds.

5. Coal-Fired Combined Cycle Power Generation Technologies

Coal-fired combined cycle power generation technologies	Order of selection	Voting rate (percent)
Coal gasification combined cycle power generation (IGCC)	1	66.7
Pressurized fluidized bed combustion combined cycle power generation (PFBC)	2	52.4
Atmospheric circulating fluidized bed combustion combined cycle power generation	3	57.1
Coal powder-fluidized bed composite combustion combined cycle power generation	4	47.6

This is a highly efficient, clean coal-fired power generation arrangement with development prospects. The main reasons for IGCC being in first place are superior environmental protection properties (it can reduce SO_x discharges by more than 99 percent) and high heat efficiency.

6. Coal Gasification Technologies Used for Coal Gasification Combined Cycle Power Generation

Coal gasification technology	Order of selection	Voting rate (percent)
KRW (fluidized bed) gasification ovens	1	80.0
Texaco (gas flow bed) gasification ovens	2	60.0
Lurgi (solid bed) gasification ovens	3	66.7

KRW coal gasification technologies have good economics properties and good adaptability to coal varieties. Moreover, there is already a foundation for Sino-American cooperation and they have developed to a relatively mature stage.

II. Coal Desulfurization Technologies

1. Pre-Combustion, During Combustion, and Post-Combustion Coal Desulfurization Technologies

Coal desulfurization during combustion	Order of selection	Voting rate (percent)
Coal desulfurization during combustion	1	85.7
Post-combustion coal desulfurization (flue gas desulfurization)	2	76.2
Pre-combustion coal desulfurization	3	81.0

The world has successfully developed and demonstrated fluidized bed combustion technologies which economically and effectively control SO_x and NO_x pollutant discharges and expand adaptability to coal varieties.

2. Flue Gas Desulfurization Technologies

Flue gas desulfurization technologies	Order of selection	Voting rate (percent)
Dry method	1	75.0
Wet method	2	65.0

The concerns in choosing dry method desulfurization are investment expenditures, operating expenditures, and secondary pollution from wastes.

III. Forecasts and Assessments of Technologies Chosen for Development

The results of this survey show that the technologies chosen for development should include: circulating fluidized bed combustion technologies, bubbling bed-circulating fluidized bed combined combustion technologies, circulating pressurized fluidized bed combustion technologies, and coal gasification combined cycle power generation technologies. The results of the forecasts are listed in the following table:

1. Implementation Time Frames and Scales

Technology	Initial scale in 1990	Ultimate scale in 2000	Extent of large-scale development and implementation time frame
Atmospheric circulating fluidized bed combustion	Demonstration	Industrial	50 MW (1991-1993)
			100-200 MW (1995-2000)
			200-300 MW (2000-2005)
Bubbling bed-circulating fluidized bed combined combustion	Intermediate testing, demonstration	Industrial	50-100 MW (1995)
			100-300 MW (2000)
Pressurized bubbling bed combustion	Intermediate testing	Industrial	100-200 MW (2000)
Pressurized circulating fluidized bed combustion	Laboratory	Intermediate testing, demonstration	50-200 MW (2005-2010)
Coal gasification combined cycle power generation with Lurgi coal gasification combined cycle	Demonstration	Industrial	125-200 MW (2000)
Combined cycle with (Deshigu) gasification	Demonstration	Industrial	100 MW (1995-2000)
Combined cycle with fluidized bed gasification	Intermediate testing, demonstration	Demonstration, industrial	100-200 MW (2000)
Combined cycle with circulating fluidized bed combustion and partial coal gasification	Intermediate testing	Industrial	125 MW (1993)

1. Implementation Time Frames and Scales (Continued)

Desulfurization during combustion (coal powder furnace)	Intermediate testing, demonstration	Industrial	200 MW (1995-2000)
Flue gas desulfurization (spray dry method)	Intermediate testing, demonstration	Industrial	125 MW (1995)
			200 MW (2000)

The results of these forecasts have the following characteristics:

—The forecast results obviously concentrate on atmospheric circulating fluidized bed combustion, bubbling bed-circulating fluidized bed combined combustion, coal gasification combined cycle power generation, and other attractive technologies, which shows that clean coal-fired power generation is extremely important for developing China's economy. Moreover, because China's electric power industry faces problems like increasing power output, reducing SO_x and NO_x discharges, aging equipment in conventional power plants, and so on, objectively this provides an excellent opportunity for China to develop these technologies.

—This forecast gives rather optimistic estimates of "implementation time frames and scales" for developing these technologies. It should be pointed out that such estimates include many uncertainties. The main uncertainties concern capital and environmental protection requirements.

—This forecast pointed out that these technologies to be developed have excellent environmental protection characteristics and can economically and effectively control pollution caused by burning coal. Moreover, attention is given to preventing SO_x and NO_x, indicating that energy resource circles in China are gradually showing greater concern for environmental protection.

—In the forecast, a lack of technical maturity, unclear market prices inside China, and other factors prevent Chinese experts from making relatively accurate forecasts and estimates of investments and costs.

—The forecast shows that a new R&D system which corresponds to new technologies for developing coal utilization is taking shape. Developers want to abandon traditional independent development by each unit and seek wider cooperation within an industry or across industries to implement joint development in China and cooperative development internationally. Government departments should encourage this proposal and provide assistance in plans, organization, coordination, and other areas to play a guiding role.

2. Environmental Protection Characteristics

Technology	Desulfurization rate, percent	SO_x discharge concentration, mg/Nm^3	NO_x discharge concentration, mg/Nm^3	Soot discharge concentration, mg/Nm^3
Coal combustion				
Atmospheric circulating fluidized bed combustion	85-90	equal to or less than 400	equal to or less than 200	equal to or less than 150
Bubbling bed-circulating bed combined combustion	85-90	equal to or less than 400	equal to or less than 200	equal to or less than 150
Pressurized bubbling bed combustion	85-90	equal to or less than 400	equal to or less than 200	equal to or less than 50
Pressurized circulating fluidized bed combustion	95	equal to or less than 400	equal to or less than 200	equal to or less than 50
Coal gasification combined cycle power generation				
Lurgi coal gasification combined cycle	85-90	350	200	30
(Deshigu) gasification combined cycle	95	<10	<10-50	<1-5
KRW coal gasification combined cycle	90 (wet method)	<50	<200	<30
	98-99 (hot coal gas purification)			
Circulating fluidized bed combustion and partial coal gasification combined cycle	90-95	<400	<200	<150

2. Environmental Protection Characteristics (Continued)

Technology	Desulfurization rate, percent	SO_x discharge concentration, mg/Nm^3	NO_x discharge concentration, mg/Nm^3	Soot discharge concentration, mg/Nm^3
Desulfurization during combustion (coal powder furnace)	similar to 50 (single nozzle calcium)			
	similar to 85 (activation moisturizing)			
Flue gas desulfurization (spray dry method)	80-95 when Ca/S = 1.5-1.6	equal to or less than 400	equal to or less than 200	equal to or less than 50

3. Technical Economics Characteristics

Technology	Combustion efficiency, percent	Heat efficiency, percent	Investment (yuan/kW)	Power generation cost (yuan/kWh)
Coal combustion				
Atmospheric circulating fluidized bed combustion	>99		1500-2000	0.05-0.08
			Slightly lower than a coal powder furnace with added smokestack desulfurization	Same as at left
Bubbling bed-circulating fluidized bed combined combustion	99 (inflammable coal)		Slightly lower than or equivalent to coal powder furnace	Same as at left
	90-95 (hard-to-burn coal)	Slightly lower than a coal powder furnace with smokestack desulfurization		Lower than a coal powder furnace with smokestack desulfurization
Pressurized bubbling bed combustion	>99			
Pressurized circulating fluidized bed combustion	>99			
Coal gasification combined cycle power generation				
Lurgi coal gasification combined cycle		38-40		
(Deshigu) gasification combined cycle		38-40		
Fluidized bed coal gasification combined cycle (KRW)		40-43	2500-3000	0.06-0.07
Circulating fluidized bed combustion and partial coal gasification combined cycle		42-45	10 percent cheaper than conventional coal powder furnace power generation	Same as at left
Desulfurization during combustion (coal powder furnace)			50-100	0.005
Flue gas desulfurization (spray dry method)			100-200	0.003-0.006

4. Research and Development Avenues

Technology	First choice	Second choice	Third choice	Fourth choice
Coal combustion				
Atmospheric circulating fluidized bed combustion	Technology importing voting rate (88.9 percent)	Development through international cooperation (55.6 percent)	Domestic combined development (33.3 percent)	
Bubbling bed-circulating bed combined combustion	Domestic combined development (75.0)	Importing (25), international cooperation (25)		

4. Research and Development Avenues (Continued)

Technology	First choice	Second choice	Third choice	Fourth choice
Pressurized bubbling bed combustion	Domestic combined development with partial imports and international cooperation			
Coal gasification combined cycle power generation	International cooperation (55.6)	Importing or partial importing (44.4)	Domestic combined development (33.3)	Independent development matched with international cooperation (a few)
Desulfurization during combustion (coal powder furnace)	Domestic combined development (75)	Independent development (25), international cooperation (25)		
Flue gas desulfurization (spray dry method)	Independent development, domestic combined with importing international cooperation (25 for each)			

Future Development of Nuclear Industry Surveyed

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[Article by Zhang Wenqing [1728 2429 7230], Lu Yanxiao [0712 1693 2556], Chen Xiaodong [7115 2556 2639], and Su Yisen [5685 1355 2773]: "Development of China's High-Technology Nuclear Industry"]

[Text] In today's world, high technology and the development of high-technology industries have become one of the main yardsticks by which a country's overall strength is judged, as well as a focal point and principal means in the international competition in intellectual and economic strength. Nuclear science and technology are a major accomplishment of scientific and technological development in this century. Nuclear high technology and the high-technology nuclear industry occupy a special strategic position in international military, economic and technological competition and will continue to play a major role.

1. Position and Effects of the High-Technology Nuclear Industry

The effects of the high-technology nuclear power industry in the national economy are manifested primarily in electric power applications and isotope and radiation applications.

Energy is the material basis of all social activity. Scarcity of energy is a worldwide problem. The stocks of petroleum and natural gas are limited, and at current consumption rates, proved reserves will last for only 30 to 40 years. Hydropower reserves are subject to geographical and seasonal limitations and will be thoroughly developed by about the year 2020. Although coal stocks are abundant, they will last only about 200 years. The use of coal is already constrained by transportation capacity, and the large-scale combustion of coal is leading to increasingly severe environmental pollution (fly ash, acid rain, acid fog, and global warming), which presents a major threat to public health and the economic environment. Scientists are strenuously urging limitations or cuts in coal consumption, and in the 1990's some countries are likely to propose agreements on limiting the burning of coal. Other new energy sources, such as solar energy, ocean energy, synthetic fuels and the like, have not reached the commercial stage. As a result, nuclear power is the only commercial energy source that is recognized throughout the world as a realistic replacement of fossil fuels; it is also the safest, cleanest, and most economical of the new energy sources. World operating experience with nuclear power, which now totals 5,040 reactor-years, proves the point. By the end of 1988, a total of 428 nuclear reactors were in operation in 26 countries and areas, with a total installed capacity of 310 million kilowatts, equal to a sixth of all worldwide electric power generation capacity. Many countries have chosen nuclear power as a major means of sustained, stable satisfaction of their energy needs. By the beginning of the next century, nuclear power will have moved up from its current fifth place in world primary energy consumption (1987 world energy breakdown: petroleum, 37.6 percent; coal, 30.6 percent; natural gas, 19.9 percent; hydropower, 6.7 percent; nuclear power, 5.2 percent) to third place, and it is likely to move into second place after 2020. There is no doubt that nuclear power is the best hope for solving the energy problem. China's energy shortage has already imposed serious limitations on overall economic development. Electric power shortages are idling about a quarter of China's production capacity. Achieving the strategic objectives for the rest of this century set by the Central Committee will require an energy equivalent of 1.6 billion tons of standard coal by the year 2000; according to current forecasts, even the most vigorous effort will provide only 1.4 billion tons, representing a large shortfall.

Although China has abundant conventional energy resources, per-capita levels are low (only half the world average per-capita figure); they have been very incompletely explored and are difficult to develop and utilize, and their geographic distribution is extremely nonuniform. Nearly 80 percent of the country's coal reserves are in the north, and only 2 percent are south of the Changjiang River. Some 70 percent of hydropower resources are in the southwest. The East China, North China and Central South regions have only 15 percent of the country's energy resources. The energy supply is extremely limited in the coastal zone and the northeast, where much of China's population and industry are concentrated.

China's current coal-oriented energy structure is urgently in need of improvement. Coal haulage is already taking up 40 percent of national freight haulage capacity, and if this trend continues it will place an intolerable burden on China's already strained transport facilities. Environmental pollution caused by coal is becoming steadily more severe and has aroused strong concern in many areas. In view of these circumstances, nuclear power is essential to China's development.

For the development of nuclear power, we must produce and supply superior-quality, low-cost nuclear fuel. A high-technology nuclear fuel cycle has already taken shape worldwide and has developed into an extensive international nuclear trading network.

Compared with the nuclear power and nuclear fuel industries, isotope and radiation technology require only a small investment, give a rapid return, and are easy to disseminate: they have been referred to the nuclear field's "light industry." They have advantages unmatched by conventional technology in such areas as information acquisition (e.g., tracers, imaging, flaw detection, component analysis, the measurement of thickness, density, weight, and the like) and materials improvement (killing insects, sterilization, disinfection, freshness protection, alteration of materials and the like), and their breadth of application is comparable with

those of modern electronics and information technology. Internationally, isotopes, isotope products, radiation processing products, the nuclear technology services industry (nuclear medicine, nuclear well logging, nondestructive testing) and nuclear equipment manufacture (research reactors, accelerators, irradiation units, nuclear treatment and diagnosis equipment) are all billion-dollar industries. It is reported that in 1985, industrial applications of isotope and radiation technology in the West gave a total economic benefit of fully $8 billion, 5 to 10 times cost. Isotope and radiation applications sprang up overnight and rapidly spread throughout the world; they are used at every stage of economic development. In China, their development will have a major effect on the transformation of traditional industrial and agricultural technologies and in promoting the development of industry, agriculture, medicine and public health, environmental protection, resource development, basic research and leading-edge technologies and will produce excellent social benefits and immense economic benefits.

2. Current Status and Progress of China's High-Technology Nuclear Industry

China's nuclear industry, like those of the major nuclear powers, began with military applications; it was created in 1955 to develop strategic nuclear weapons and submarine propulsion. In the last 30 years, first-generation atomic and hydrogen bombs and nuclear submarines have been developed and have become operational, major progress has been made in developing second-generation nuclear weapons, and there have recently been new breakthroughs. Starting from scratch, we have gradually developed a complete and integrated military nuclear system comprising geology, mining, hydrometallurgy, uranium concentration, reactor components, plutonium production and postprocessing, special instruments and equipment, construction and installation, and nuclear weapons plants, together with research, design, education, medical treatment and public health systems for each industry component. We have trained a large contingent of nuclear science and technical personnel with excellent political and professional qualifications and have laid down the material and technical foundations for China's further progress in nuclear weapons and the peaceful use of nuclear energy. China has made its first steps in nuclear power plant construction. As of the end of 1988, China had 233 nuclear industry enterprises and services, employing more than 300,000 persons, including 72,000 scientific and technical personnel, 33,000 of them with advanced or secondary technical education, offering a superior ability to handle scientific research tasks.

China has had noteworthy achievements in military nuclear applications, but in the civilian sector it has not yet mastered large-scale nuclear power plant technology and has not yet completed a single nuclear power plant; breakthroughs are needed in certain key technologies of the nuclear fuel cycle, and small production scale, low efficiency and high costs are still major problems.

Although isotope and radiation technology have been applied to varying degrees in such fields as agriculture, industry, medical treatment and research, and although outstanding results have been achieved in some areas, in overall terms Chinese nuclear technology is small scale and backward.

Since the 3d Plenary Session of the 11th Central Committee, in response to the Central Committee's instruction "while still according priority to military uses, shift the focus to promoting national economic development and the people's livelihood," the nuclear industry has drafted a program of "integrating military and civilian efforts, with primacy to nuclear power, and diversified operations," and has embarked upon a strategic shift that constitutes a second founding. During the Sixth and Seventh 5-Year Plans, the nuclear industry carried out a comprehensive retrenchment and readjustment, suspended construction on a group of large-scale projects and factories and mines, made large cutbacks in military products, and shut down or retooled many plants and mines. At the present critical time, which will determine the nature of the nuclear industry's future development, formulating a correct development strategy, choosing strategic objectives, rationally readjusting industry structure, product structure and coordinating research and production capacities are essential in order to protect and develop China's activity in the nuclear field.

China is both a nuclear country and a socialist country, and we hold the balance in the international political situation. As a result, the development of our high-technology nuclear industry must maintain the double objectives of military and civilian uses consistent with this position and we must create an industry of respectable size and use nuclear technology to reform traditional industries.

Given the current trends, China should form high-technology nuclear industry clusters in several areas, namely: the nuclear weapons industry, the civil nuclear power industry, the nuclear fuel cycle industry, and the isotopes and radiation technology industry.

a. The Nuclear Weapons Industry

With China's limited resources, it need only maintain a limited nuclear deterrent force and establish a small but high-quality nuclear weapons industry with strong research and development capabilities. The key is to keep up with the world state of the art. We must lay foundations, raise our level, increase the capabilities and quality of nuclear weapons and nuclear power, maintain a certain reserve capability and production capacity, and replace and modernize our nuclear weapons arsenal.

b. The Civil Nuclear Power Industry

Starting in the early 1970's, China made preparations to construct nuclear power plants, but owing to the lack of a clear understanding of China's energy situation and an attitude of blind optimism, combined with various degrees of doubt regarding the safety and economic

benefit of nuclear power plants, it was not until 1983 that construction of China's first nuclear power plant, the 300,000-kW plant at Qinshan, was begun; construction of the two all-imported 900,000-kW generating units at Dayawan, Guangdong, was begun in 1984. The construction of two 600,000-kW nuclear power generating units received state approval in 1987, and the first stage of preparatory work on these plants is under way. Even though the advance of China's nuclear power industry has been slow and arduous, a beginning has been made. Given China's technical and economic circumstances, its mid- to long-term strategy should be to develop power plants with pressurized-water reactors by the end of the present century; this is a mature technology abroad, for which a domestic foundation has already been laid. In the coastal zone and the northeast, which are economically developed but energy-poor, we must proceed with vigorous, focused, systematic construction: both as a source of supplementary energy to meet the urgent needs of economic development and in order to master fully the design, construction and management of nuclear power plants; in addition, we must make a vigorous effort at standardization and lot production, gradually mastering the domestic production and creating the beginnings of a full-fledged industry.

c. The Nuclear Fuel Cycle Industry

China's nuclear fuel cycle industry has now taken preliminary form, comprising geology, mining, hydrometallurgy, chemical engineering, uranium concentration, fuel element manufacture, nuclear fuel postprocessing, and waste management, but its scale is still small and its economic performance inadequate. To attain the goal of a commercial-scale, high-technology industry, we must adjust, modernize and optimize, as well as further expanding our production capabilities. Nuclear fuel development in China must adapt to the speed and scale of nuclear power plant construction, match the pace of auxiliary construction to it, and organize its scale so as to appropriately coordinate immediate deadline production and future needs. Technologically, the key focuses are uranium concentration, fuel element construction, and postprocessing.

d. The Isotope and Radiation Technology Industry

Isotope and radiation technology are used in an extremely wide range of fields and involve a wide range of possible application products; and China's scientific and technical personnel are now working in most of these areas. About 200 major units are engaged in isotope and radiation technology production or applications, with about 2,000 direct applications organizations and about 20,000 specialized personnel, covering the whole of industry, agriculture, medicine, environmental protection, resources, military uses, scientific research, and education.

China has had especially significant radiation technology achievements in agriculture, and extensive applications to medical treatment have been developed; but industrial applications and radiation processing are rather scattered and backward. Some units have approached or reached the world state of the art. In agricultural applications, for example, by 1986, radiation had been used alone or in combination with other methods in the breeding of 23 different plants, yielding a total of 243 breakthrough varieties, or fully 30 percent of all such varieties worldwide, an achievement that places China first in the world. The new crop varieties are now being grown on a total area of 147 million mu and have increased benefits by 2 billion yuan. But overall, China's technological level is still rather far behind the economically developed countries, as expressed by the fact that many technological results are still in the intermediate trial-production or small-scale production stage, the pace of commercialization of results is slow, and economic benefits have not been fully realized. In the near term, China's isotope and radiation technology development strategy should be "limited objectives and breakthroughs in key areas"; and while continuously increasing the rate of dissemination of medical uses and expanding application results in agriculture, we must emphasize commercialization of industrial applications, focus of middle- and low-grade products for the near term, and keep pace with leading-edge technologies.

Need To Develop Nuclear Power Stressed

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[Article by Jiang Shengjie [1203 5110 7132] of the Chinese Nuclear Society, Beijing: "The Urgency of Developing Nuclear Power in China and Some Issues of Concern"]

[Text] **Abstract**

This article describes the necessity and urgency of developing nuclear power in China on the basis of China's energy resource conditions. It illustrates the advantages of nuclear power by comparing it with coal-fired power and hydropower. It also describes a stress on long-term planning, accelerating the shift to domestic production and standardization, developing new reactor types, tracking advanced world technologies, and other issues that China's nuclear power should be concerned with in the areas of technology, capital, personnel, the environment, economics, and others, and it points out development directions for nuclear power in China.

Key words: nuclear power, long-term planning, shift to domestic production, standardization

Energy resources are an important material foundation for developing the national economy and improving people's living standards, and they are a primary aspect of economic construction. Nevertheless, the electric power shortage seriously restricts development of our national economy. China has had an electric power

shortage for quite some time and the extent of the shortage continues to grow. The power shortage has grown from an estimated 40 billion kWh (equivalent to an installed generating capacity of 10,000 MW) in 1980 to an estimated 70 billion kWh in 1987 (equivalent to an installed generating capacity of 15,000 MW). The electric power shortage is now even more acute. Urban areas and plants in many cities experience frequent power outages. They shut down for 3 days and operate for 4 each week. Almost 20 percent of our industrial production capacity cannot be utilized. The loss in value of output exceeds 100 billion yuan. Some provinces and municipalities have had power shortages for over a decade but now we have a universal national power shortage. A primary reason for the failure of electric power construction to keep up with economic development is that everyone uses power but there is only one developer of power, and state investments in electric power have been insufficient. The gross value of industrial and agricultural output in China increased 16 percent in 1988 but electric power grew by just 7.6 percent, far from adequate to meet the needs of economic construction. Analysis of the relevant data shows that China's energy shortage will persist for quite some time into the future. This is a mistake in planning and policymaking, and it has created a vicious cycle.

Originally, the price of electricity should have included funds needed to develop electric power. China has implemented a policy of low power prices and high tax rates which have resulted in enterprises lacking the capacity for self-development. In foreign countries, to ensure present and future demand for electric power by users (a legal responsibility), electric power companies must have an installed generating capacity which exceeds peak loads at all times. China has become accustomed to power shortages. This is certainly unfavorable for economic and social development and the losses are hard to estimate.

Very long construction schedules for power plants mean that operating time limits are also quite long. Electric power departments should begin with demand and formulate long-term plans. China's previous electric power plans were not sufficiently integrated with our development strategies. They stressed the supply side without giving adequate attention to the demand side. At the same time, they mainly involved short-term plans and neglected long-term plans. This sort of situation made hydropower and nuclear power development very difficult. Present "long-term plans" only take the period up to 2000 into consideration, so it of course is difficult to change the electric power energy resource structure. According to estimates by comrades in the Ministry of Water Resources and Electric Power, if we can still compel preservation of an electric power structure dominated by coal burning (coal produces 75 percent of our power output), hydropower development will become exhausted in the earlier part of the 21st century and coal-fired power will be restricted by transport, extraction and other factors involved in using coal, so major efforts to develop nuclear power will be unavoidable. We hope to be able to complete 10,000 MW of nuclear power plants each year after 2015 and shift to fast neutron reactor nuclear power plants after 2030. Although this still cannot be considered a long-term plan because many factors like the burden of environmental pollution, regional development, electric power supply and demand, and so on have not been considered in detail, one can already see that:

1. Although China has abundant coal reserves, it will be hard to meet demand for energy resources as our population grows rapidly. The distribution of China's coal resources is extremely irrational. They are mostly concentrated in the "three wests" (Shanxi, Shaanxi, and western Inner Mongolia). Using the Beijing-Guangzhou railway as a dividing line, 15 percent of our proven reserves are in east China and 85 percent are in west China. Using Qinling and Dabie Shan as a dividing line, north China has 94 percent and south China only 6 percent. The inevitable result of this configuration is shipping north China's coal to south China and west China's coal to east China. Railway coal transport now accounts for 40 percent of the total volume of freight hauled on China's railroads, which has intensified the shortage of railway transport capacity. Moreover, the extraction of China's coal is poorly managed. Individuals, collectives, and the state push forward together, so there is a lack of unified planning and management. Some individual and collective coal mines extract their coal in a destructive fashion and are concerned only with immediate benefits, lacking a long-term perspective. Since 1988, many power plants have announced coal supply emergencies and some coal mines basically have no coal on hand. Forecasts by authoritative experts show that demand for coal in China will increase from 970 million tons in 1988 to 1.4 billion tons in 2000. If we fail to adopt effective measures now, there will be extremely serious energy and transport shortages when that time comes.

2. Developing nuclear power is the basic way to reduce energy resource shortages in China's coastal and industrially developed regions. An energy resource structure dominated by coal creates more than transport shortages. It also intensifies atmospheric pollution, acid rain, and the greenhouse effect. China now discharges over 1 billion tons of carbon dioxide and over 28 million tons of soot into the atmosphere each year. Warming of the earth's climate by the greenhouse effect has already aroused the concern of scientists and relevant public health organizations throughout the world. They have warned that growing amounts of carbon dioxide, methane, and other compounds in the atmosphere are now creating a global heat casing which will create instability in global air temperatures. For this reason, it is extremely necessary that energy resource policies designed to help stabilize the climate be adopted and that new energy resources be found to replace mineral fuels. Thus, we should try to develop nuclear power and other renewable energy resources like solar energy, wind

power, bioenergy, geothermal, and other energy resources. Authoritative climatic experts in England announced in early February 1989 that 1988 saw the highest atmospheric temperatures in this century. Since the industrial revolution, as the scale of mankind's economic construction has continued to expand, the effects on the environment have spread to a global scale and to very deep layers of space. There has been an abrupt increase in the content of carbon dioxide and other so-called greenhouse gases in the atmosphere (40 percent of which is carbon dioxide). In 1958, the United States began continuous measurements of carbon dioxide concentrations at Hawaii. The results show that the atmospheric carbon dioxide concentration was 315 ppm in 1958 and 343 ppm in 1984. From 1968 to 1978, the average yearly rate of increase in carbon dioxide exceeded 1 ppm. If it continues to increase at this rate up to the year 2000, the atmospheric carbon dioxide concentration will reach 600 ppm, and the effects can be imagined. Moreover, many experts feel that the impact of the greenhouse effect on the human environment will not be limited to this. The effects will be even broader and more profound. The greenhouse effect may increase moisture evaporation, which would affect mankind's water supplies and sea level changes would change the spawning laws of fish and cause some plants to become extinct. Of course, the greenhouse effect I speak of here is not due solely to the effects of coal-fired power plants. The effects are also created by ever-increasing numbers of boilers, household coal stoves, and other coal burning, so thermal power plants are merely one component. This is also true for acid rain. In summary, we must build nuclear power plants in the not-too-distant future in China's densely populated Chang Jiang delta, the relevant provinces and municipalities of south China, new economic development zones, and other regions with energy resource shortages.

II. Issues of Concern in Nuclear Power Development in China

It is extremely urgent that we begin working between now and the year 2000 to shift to domestic production and standardization of nuclear power plants. Still, proper arrangements have not been made yet to develop nuclear power and our progress is slow. On the basis of the causes for this, we should be concerned with these points:

A. Long-Term Planning Is Even More Essential for Nuclear Power Compared to Other Types of Electric Power Construction

Building nuclear power plants involves long construction schedules and huge capital construction investments, but China still lacks experience in building and operating nuclear power plants. Understanding the technologies involved and accumulating experience will require additional time and investments. Plans to guide nuclear power development should at least make arrangements up to the year 2015. Making arrangements up to 2000 is not sufficient. However, China still lacks a regular long-term plan for nuclear power which makes unified considerations.

Simply doing feasibility research and submitting applications for approval for a few projects without having comprehensive plans for nuclear power construction is inappropriate because nuclear power initially requires enormous inputs of manpower, materials, and financial resources far in excess of expenditures for nuclear power plant construction. The benefits of these inputs would not seem to be worthwhile for just one or two nuclear power plants. For this reason, it will be meaningless to speak of making a firm decision to develop nuclear power if we fail to compare all types of electric power energy resources to determine the proportion and development speed for nuclear power within the scope of long-term plans for electric power as a whole and do not begin with objective requirements and possibilities in scientifically debating the necessity and urgency of developing nuclear power because this firm decision will be without foundation. The two rises and two falls in China regarding nuclear power plants over the past 10 years are due to inadequate debate.

The International Atomic Energy Agency is extremely concerned with research on plans in developing nations before they begin developing nuclear power. It feels that this type of research must be integrated with all possible forms of power generation and with a nation's economic development and energy resource requirements, and carried out in an integrated manner. The organization is especially concerned with forecasts of future demand and feels that problems in all areas including technology, economics, capital, personnel, the environment, industrial foundations, and social problems must be considered to confirm that developing nuclear power is the most economical choice. China failed to do extensive research of this type in the past, and the result is a lack of unified understanding of the status of nuclear power in China's energy resources and the relationship between nuclear power and economic development. It is easy to waver whenever a problem is encountered. This is very harmful for developing nuclear power.

B. Focus on Problems With Nuclear Power Technologies

There are two problems in construction of nuclear power plants. One is the high quality requirements (nuclear grade) for most equipment, components, and instruments to satisfy requirements for nuclear power safety, reliable operation, and inexpensive power generation costs. The second is assembly of equipment, components, and instruments into an integral nuclear power plant with a high degree of safe, reliable, and economical operation. This places special demands on engineering design, civil engineering and installation, project management, safety application and approval, debugging, and startup that are different from those for conventional thermal power plants. If one can say that the former involve hardware technologies, then the latter

can be called software technologies. It is often easy for people to neglect software by feeling that if they have the hardware, they have everything. The reality is otherwise because a nuclear power plant is a large modern, comprehensive, and complex project. To compensate for China's inadequate experience and technology, we should do development research, import technologies from foreign countries, or a combination of the two. Whatever the case, it always requires additional investments. This money can only be compensated for through a series of nuclear power plant projects. It should not be calculated in the accounts of one or two nuclear power plants.

C. Accelerate the Shift to Domestic Production and Standardization

Similar problems are also involved in the shift to domestic production and standardization. The benefits of a shift to domestic production and standardization are only apparent in subsequent nuclear power plants and more money must be spent at the beginning. The government should formulate concrete policies to encourage the shift to domestic production of equipment and provide preferential treatment through tax exemptions, subsidies, and so on to motivate enterprise initiative for trial manufacture of this type of nuclear power plant equipment with high quality requirements, great technical difficulty, and small production amounts. For example, China is now building two nuclear power plants. Domestic production of equipment is required only for Qinshan Nuclear Power Plant. Producing this type of equipment, however, will require construction of a plant building and the purchase and construction of associated facilities for the relevant research and experimentation. In spending these considerable funds, if we only produce a single set of nuclear equipment for Qinshan Nuclear Power Plant and the state does not provide subsidies and preferential treatment and does not prepare long-term plans and calculations, this type of loss-making business will prevent the plant from moving forward. Moreover, it is too unreasonable to calculate all these costs for the Qinshan Nuclear Power Plant alone. This is not the first time we have encountered a dispute over whether to buy a chicken which will lay eggs or buy the eggs directly. For this reason, a shift to domestic production of nuclear power equipment will require larger initial investments. The benefits of these investments will become apparent later.

D. Focus on Building the Two Plants, Grasp Technologies, Gain Experience

Guangdong's Daya Bay 2 X 900 MW and Qinshan 300 MW nuclear power stations now under construction are the only source of valuable experience and excellent opportunity we have. We should integrate experiences at these two types of nuclear power plants and two types of methods and integrate the experience with research work related to long-term nuclear power plans (within the framework of long-term energy resource and electric power plans) in searching for concrete and clear methods and steps to take in developing nuclear power in China. This work itself is an important soft sciences research topic. It also may suggest certain S&T topics like how to adapt safety standards, design criteria, and generating unit scales to China's national conditions, assessment of our existing industrial foundations (including the manufacturing industry and nuclear fuel industry), plans for shifting to domestic production, plant site surveys, relationships of nuclear power plants to power grids, analysis of power generation costs, the international nuclear trade (including equipment and fuel) situation, international capital raising issues, technology transfer issues, advanced reactor types for the next stage of development, a transition to fast neutron reactors, and so on, all of which should receive our attention.

E. Seize a Favorable Opportunity, Develop in the Excellent Situation

In his report on political work at the 2d Session of the 7th National People's Congress, Premier Li Peng pointed out that the electric power industry should adhere to the principle of everyone developing power, adapt to local conditions to develop thermal power, hydropower, and nuclear power, and strive to increase the capacity for electric power production. At the National Energy Resources Work Conference convened jointly by the Ministry of Energy Resources and the State Planning Commission, State Council member Zou Jiahua [6760 1367 5478] stressed the importance of developing nuclear power. At present, besides Daya Bay Nuclear Power Plant and Qinshan Nuclear Power Plant now under construction in China, the state has approved construction of two more commercial nuclear power generators with an installed generating capacity of 600 MW at Qinshan. Construction is expected to begin in 1990 and they will be completed and go into operation around 1995. Liaoning Province is also proceeding with preparations to import a PWR nuclear power plant from the Soviet Union and the site selection and discussions have already started. Scientific and technical experts from the Soviet Union's nuclear industry also have visited China to understand the situation. Jiangsu Province also is actively requesting importation of a CANDU heavy water reactor nuclear power plant from Canada. Because Jiangsu and Canada's Ontario Province are sister provinces, they may receive some preferential treatment in the area of prices and loans. Several provinces and regions are also requesting construction of nuclear heat supply reactors. I feel that we should utilize the favorable conditions of the first stage of Guangdong's Daya Bay plant and build another large-scale nuclear power plant. This would conserve investments and could accelerate growth in the economic development zone and satisfy its demand for energy resources. The ability of the nuclear power situation to develop so quickly today is inseparable from China's present energy resource and coal shortages. However, the state should make unified arrangements concerning which of these projects to pursue first and which later. Recently, while inspecting Qinshan Nuclear Power Plant, State Council

member Comrade Zou Jiahua called Qinshan Nuclear Power Plant a "national honor" and pointed out that construction of the nuclear power plant should be the responsibility of the Nuclear Industry Corporation. In addition, Comrade Jiang Xinxiong [5592 1800 7160] was added to the State Council's Nuclear Power Leadership Group as deputy group director. We certainly should seize this favorable opportunity under leadership of the new nuclear power leadership agency to develop the excellent situation and create a new situation in nuclear power construction.

F. Study and Develop New Types of Reactors, Track Advanced World Technologies

In the area of nuclear power construction, China is over 20 years behind world nations with developed nuclear power. The substantial amount of work we are doing now to begin building nuclear power plants was done by others over 20 years ago. If we stop now at this foundation, we will discover 20 or 30 years from now that everyone will have moved up to a new stage and the distance between China and nations with developed nuclear power will be even greater. For this reason, we should begin now to study and develop new technologies and new reactor types. Foreign countries, for example, are now focusing on simplifying the design of advanced PWR, reducing the amount of equipment required to provide them with good safety, short construction schedules, a high degree of standardization, and a relative reduction in cost. Other examples include fast neutron reactors and nuclear heat supply reactors. Although China has not yet built them, we should grasp the technologies and begin working on them immediately when the opportunity arises and we have the funds. We should grasp the technologies and wait for opportunities, not grasp the technologies whenever the opportunity arises.

G. To Solve the Energy Resource Crisis and Increase Imported Electric Power Supplies, We Should Adhere to the Principle of Combining Development and Conservation

The efficiency of energy consumption in China is far lower than in developed nations. China consumes 2.97 tons of standard coal per $1,000 in value of output. In contrast, the United States, the Soviet Union, and Canada need only about 0.8 ton and Japan, France, Federal Germany, and England need only 0.3 to 0.4 ton of standard coal. China consumes over 1.6 kWh of electricity per $1.00 in value of output, whereas France, Federal Germany, and other countries consume less than 0.5 kWh. Doubling the efficiency of electricity use would be equivalent to building another power plant of several 1,000 MW. Civilian consumption accounts for very little of the electricity used in China. Most of it is used in industry. Thus, increasing the efficiency of electricity utilization in industry is extremely important power conservation work. To improve the quality of management in this aspect of electricity conservation work, we must spend large amounts of capital to improve old machinery and equipment. The investments would be substantial, but everyone should understand clearly that this is a far-sighted tactic.

In examining development of the world's nuclear power industry, parameters provided by the International Atomic Energy Agency show that 417 nuclear power plants with a capacity of about 298 GWe were in operation worldwide at the end of 1987. A total of 429 nuclear power plants with a capacity of about 311 GWe were in operation worldwide at the end of 1988. In terms of electric power, these nuclear power plants generated 1,652 TWh in 1987 and 1,794 TWh in 1988. Nuclear power accounted for 16 percent of total world power output in 1987 and 17 percent in 1988. Compared with the past, the 1,652 TWh of electricity generated by nuclear power in 1987 was 1.2 times the total amount of power generated worldwide in 1954, and was the equivalent of supplying 6.44 billion tons of coal. The amount of electricity generated by nuclear power in 1988 was 1.3 times the total amount of power generated worldwide in 1954, and was the equivalent of supplying 6.97 billion tons of coal. Projections by relevant experts show that the world will have 480 nuclear power plants in operation by 1990 with a total capacity of 353 GWe.

It is apparent that developing nuclear power in China is a trend of the times. We should begin now to formulate a perfect long-term plan to develop nuclear power. This plan should include the speed and scale of nuclear power construction as well as uranium ore prospecting and mining, adopting advanced technologies to increase concentrated uranium production, R&D on advanced pressurized-water reactors, fast neutron reactors, and nuclear heat supply reactors, depleted nuclear fuel processing and nuclear waste storage, selection of development of several standardized types of nuclear power plants with good inherent safety, large-scale training of new nuclear technology personnel, and so on. Only in this way will it be possible to establish a winning position in future development and competition, meet the needs of the people's livelihood and four modernizations drive in China, and accelerate the pace of socialist modernization and construction.

Speed-Up Planned for Construction of Nuclear Power Plants

40100059B Beijing CHINA DAILY in English 22 May 90 p 1

[Article by staff reporter Li Hong: "Speed-Up Planned for Nuclear Energy"]

[Text] China is planning to speed up the construction of nuclear power plants in an effort to make up for the country's energy shortage, a senior government official said yesterday.

The China National Nuclear Corporation (CNNC) is targeted to have plants supplying 6,000 megawatts of nuclear power generators in operation by the end of this

century. Two plants, one near Shanghai and one in Guangdong Province, are already under construction.

In addition, CNNC hopes to have additional plants with a total capacity of another 6,000 megawatts under construction, said CNNC Executive Vice President Chen Zhaobo.

Chen said the first Chinese-designed nuclear power plant, the first phase of the 300,000-kilowatt pressurized water reactor Qinshan Station, will generate electricity by the beginning of next year, which will be followed by other plants in the country's coastal provinces.

And the country hopes to master the design, construction, assembly, testing and management of a 600,000-kilowatt pressurized water reactor plant, which is likely to be the mainstay of the country's nuclear power development.

Also, according to Chen, the country is pinning much hope on finding new uranium deposits and increasing its uranium reserves. To date, more than 200 deposits of different types have been discovered.

It is expected that China's nuclear power will be developed at a much quicker pace, and efforts on uranium prospecting and exploration will be furthered in the 21st century.

Chen spoke at the annual technical committee of the Asia and Pacific Uranium meeting yesterday in Beijing.

"The current uranium over-supply in the world market, caused by oil price reductions and the negative effect of the Three Mile Island and Chernobyl accidents, is a temporary phenomenon," said Chen who is also a renowned nuclear specialist.

Sponsored by the International Atomic Energy Agency (IAEA) and hosted by CNNC, the session was attended by more than 100 uranium experts and officials who came from 18 IAEA members including India, Pakistan, Japan and South Korea.

During the meeting, which will last three days, international specialists on uranium geology are scheduled to discuss the characteristics and important recognition criteria of uranium deposits in the different geological environments in the Asia-Pacific region, and then seek out the implications for resource evaluation and exploration in the area.

It is learned that Chinese uranium geologists will present 14 out of the total 30 papers, systematically introducing the uranium geology in China and the research results obtained in the past years, which is thought "of value for reference to the experts of other countries, particularly Asian states neighboring China."

China started uranium prospecting and exploration in 1955. Now it is home to a complete set of uranium prospecting and exploration methods and an experienced exploration team of more than 60,000.

Qinshan Could Be Operating by March 1991

40100059a Beijing CHINA DAILY (The Municipality) in English 11 Jun 90 p 3

[Article by staff reporter Chen Qide: "Final Test for First Nuclear Plant"]

[Text] The country's first nuclear power plant is expected to start operation next March, according to Wu Moxin, an official with the Shanghai Nuclear Power Office.

All the equipment had been installed and if the thorough examination currently in progress proved satisfactory, the plant would be able to generate electricity next March, three months later than scheduled, said Wu. Built with an investment of 1.2 billion yuan ($255 million) from the State, the Qinshan Nuclear Power Plant—located in Zhejiang Province—will have a generating capacity of 300,000 kilowatts.

The plant, which has an army of 4,000 technicians and workers, is independently designed and built. More than 80 percent of the equipment was from the city, said Wu, adding that only a few key components were foreign, mainly from Japan, France, West Germany, and the United States.

Nuclear fuel from Sichuan Province would be put into the reactor container this September, he added.

Experts from the International Atomic Energy Organization had made a strict examination of the nuclear plant and shown their satisfaction with it, he said.

According to the original plan, two 600,000-kilowatt nuclear plants were to be built when the Qinshan Power Plant was put into operation.

But due to a shortage of funds and last year's June event, the projects had to be stopped, Wu said.

In view of this, the city was preparing to construct two more 300,000-kilowatt nuclear plants at Qinshan Hill which were expected to cost about 2.6 billion yuan ($552 million). "The projects are promising but are awaiting approval," he said.

Conditions of Site of Proposed Liaoning Plant Described

906B0051B Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 11 No 1, 10 Feb 90 pp 14-18; manuscript received 10 Apr 89

[Article by Yan Guangjun [7051 1639 0689], Jiang Shaoxin [5592 4801 2450], and Wang Xiaoming [3769 2556 2494] of the Northeast China Power Industry Management Bureau, Shenyang: "Liaoning Nuclear Power Plant Site"]

[Text] **Abstract**

This article describes the seismology, geology, hydrology, environment, communications and transportation, and other conditions of the Liaoning Nuclear Power Plant

site, and it makes specific assessments and describes the safety and reliability of the plant site.

Key words: regional stability, seismological, geological, and natural conditions, communications and transport

I. Introduction

Work for planning and plant selection for Liaoning Nuclear Power Plant began in March 1978. A total of 13 sites were chosen along the Huang Hai coast of Liaodong Peninsula and the coast of Liaodong Bay in Bohai Sea. After sifting through them, two preliminary sites for the nuclear power plant were recommended at Xudabao in Xingcheng County and Wentuozi in Fuxian County. This article mainly describes conditions at the Xingcheng Xudabao plant site.

II. Regional Stability

This region is centered on the middle point of a line connecting the two plant sites and covers a radius of 300 kilometers. The total area covers about 282,700 square kilometers. It includes parts of Liaoning, Hebei, Shandong, and Jilin provinces, Inner Mongolia Autonomous Region, and Tianjin Municipality, as well as two marine areas in Bohai Sea and north Huang Hai.

A. Tectonic Location and Analysis of the Crustal Structure

The region is located on the Sino-Korean paraplatform south of 42°30' N latitude in a crustal area of stable activity. There has been no intense structural activity in the paleobasement outcrop region in the middle of the platform region since the Sinian period (700 million years ago), and it is a relatively stable region of primarily uplifting and subsidence activity. The paleobasement is characterized by solid rock, integral middle and lower strata positions in the crust, good continuity, strong stability, and the absence of enormous deep fractures and obvious structural diversity. The composite granite of the two plant sites is capped by non-folded level capping strata of a Qingbaikou system or Sinian system monocline, which indicates the absence of intense structural activity in this region since the Sinian. It mainly experienced gentle uplifting at a rate of 2 to 3 mm/a.

The primary paleostructural zones which outcrop from the paleobasement on the south and north sides of Yin Shan latitudinal structural zone are relatively stable zones. The two plant sites are located on paleostructural systems of the primary zone on the south side of the paleobasement outcrop of the latitudinal system. It is a relatively stable block.

The depth contours of the Moho layer and magnetic strata boundaries indicate that the two plant sites are located in a relatively flat gently sloping zone of the Moho layer. The depth of burial of the magnetic strata boundary in this region generally varies from 8 to 20 kilometers (depths of 0 to 2.8 kilometers are shallow strata magnetic bodies and depths greater than 3 kilometers are deep strata magnetic bodies). The Xudabao plant site is located on a flat-topped platform rock 10 kilometers deep with a nearly east-west strike. The majority of the distribution of strong earthquake epicenters are located on the steeper depths of the magnetic strata boundary and marginal areas of relative depressions and uplifts.

The tectonic location and crustal structural characteristics indicate that the two plant sites are located in a relatively stable region.

B. Regional Structural Conditions and Fracturing Activity

Two fracture zones (Shanyi-Kuanchen-Jinzhou fracture zone and Hun He-Tangu fracture zone) northwest of the Xudabao plant site do not pass through the area of the plant site.

Although Lingjiao He Mesozoic basin is located northwest of the plant sites, it is small in scale and gentle, and no large fractures or folds have been discovered. Although there are faults and mylonite on the paleobasement, the scale is small and no new periods of structural activity are evident. Taohua Island fracture is 16 kilometers from the plant site and no unusual activity between the island and mainland was discovered. Comprehensive analysis indicates that it is a relatively stable area.

Tanlu fracture: The northward-extending portion of Tanlu fracture does affect this region. It passes through Bohai Sea to the Lower Liao He plain and Shenyang and extends on to the north. Although there was very strong fracture-subsidence activity and volcanic activity in the northward-extending part during the early part of Xi Shan movement, seismic exploration data confirm that extremely few faults between Bohai Sea and the Lower Liao He dissect the upper Tertiary or Quaternary systems. Analysis of geomorphological charts of the marine area and developmental characteristics of the sea platform shows no traces of obvious fracturing activity since the upper Pleistocene. There are no indications of disturbance of the Quaternary system which caps several primary trunk fractures to the north of Shenyang, and it has been deduced from this that the activity became weaker moving further north from the northward-extending part after the Neogene. No significant structural activity was apparent after the beginning of the Holocene. Thus, the locations of the plant sites on both sides of the Tanlu fracture zone are in relatively stable regions.

Longquansi fracture: Only Longquansi fracture covers a rather large scale at the Xudabao plant site. It is 12 kilometers long, but it is not an active fault and there are no active fractures.

C. Regional New Structural Activity

New structural activity which began after the Neogene played an enormous role in changing and transforming the modern crust and laid the basic foundation for the modern geomorphology. Based on the requirements of nuclear power plant safety laws and regulations, new structural activity deserves special attention and should be the focus of detailed research.

1. Geothermal and volcanic activity. Volcanic activity has weakened since recent times and no modern volcanic activity was discovered within 200 kilometers of the plant site.

Altogether, there are 72 hot spring sites in the entire region, but they continually release their energy through geyser eruptions, which reduces accumulation of thermal energy and increases crustal stability factors. Underground convection is lower than the world background value (6.28 $\mu J/cm^2$ x s) and slightly higher than world stable regions (under 4.18 $\mu J/cm^2$ x s).

2. Uplifting and subsidence activity and stress values. Crustal deformation, marine intrusion, and other things indicate that this was a region of gentle and slow lifting since the Quaternary. The stress value for the Hebei region is 11.8 to 64.7 MPa, which shows that it is not large at the Xudabao plant site.

III. Seismogeology

A. Basic Intensity at the Plant Sites

1. Effects of powerful earthquakes in surrounding areas. During the 1976 Tangshan earthquake, the plant sites and adjacent regions were outside of the magnitude 6 Tangshan earthquake region, but magnitude 6 to 7 anomaly points did appear here. There were two magnitude 7 anomaly points within 20 kilometers of the plant sites but the earthquake destruction indices are less than 0.1 (the earthquake destruction index for magnitude 7 is 0.11 to 0.307). Thus, the effects of the Tangshan earthquake on the plant sites were set as magnitude 6. The effects of other earthquakes on the plant site were all magnitude 5 and less.

2. Latent epicenters and their effects on the plant sites. Latent epicenter regions were determined using the seismogeology indicator category comparison method, seismic activity analysis, and comprehensive analysis using the graphic identification method.

Bozhong [central Bohai Sea] subsidence in the Tancheng-Yingkou fracture zone is a level 7 earthquake risk region. Considering the intensity of an epicenter 128 kilometers from the plant sites as a magnitude 9, it would create magnitude 6 effects on the plant sites. Comprehensive analysis of the latent epicenter region indicates that it would create magnitude 6 effects on the plant sites.

3. Background seismic effects. Background seismic effects refer to the certain amount of temporal and spatial indeterminancy of certain earthquakes within a particular region or zone which make it very difficult to differentiate their relationship with what types of special structural positions. Earthquake resistance regulations in foreign countries state that whenever there is no apparent relationship between the historically strongest earthquake intensity sites or epicenters and tectonics, it should be assumed that these earthquakes occur at the plant site and that the epicenter is usually 15 to 20 kilometers beneath the plant site. This is the depth of maximum risk. If this type of earthquake occurs at the plant site, it will create magnitude 5 to 6 effects. Comprehensive analysis indicates that the basic intensity at the Xudabao plant site is magnitude 6.

B. Seismogeology and Engineering Geology

Of the strong earthquakes which have occurred within a range of 190 to 220 kilometers of the plant sites, there have been no earthquakes greater than or equal to magnitude 5 within a range of 30 kilometers of the plant sites and no earthquakes greater than or equal to magnitude 1 within a range of 10 kilometers of the plant sites. In a region of a magnitude 6 basic earthquake intensity, the reactor safety shutdown peak earthquake value surface acceleration is 0.16 g and the operational criterion earthquake is 0.08 g.

The primary lithology is biotitic gneiss, biotite mixed with granite, and augen migmatic granite. The pressure resistance of the rock is 1.22 to 2.60 GPa, the elasticity modulus is 372.7 to 657.0 GPa, and the ground endurance is in the 50 t/m^2 geologically stable ground stage.

IV. Natural Conditions

A. Plant Site Location

The Xudabao plant site is located on the west coast of Liaodong Hai 33 kilometers from Xingcheng and 19 kilometers from the Suizhong County seat at 120°32' east longitude and 40°21' north latitude. The natural datum mark at the plant site is 5 to 20 meters, the slope is 3 percent, and the design datum mark is 8.5 meters. The terrain in the area of the plant site is flat and broad and four or more large generators can be installed there, occupying 565,000 square meters of land.

B. Climatic Conditions

Wind direction and wind speed: The primary wind direction is from the SSW and the secondary direction is from the south. It shifts to a SSW wind direction during the summer and to a northerly wind during the winter. The 10-year average wind speed is 2.9 meters/second and the 30-year maximum wind speed is 26.3 meters/second.

Temperature: The mean annual temperature is 8.8°C, and the maximum monthly mean temperature is 23.6°C and the minimum is -8.0°C. The extreme maximum temperature is 40.8°C and the extreme minimum temperature is -25°C.

Humidity: The mean annual relative humidity is 65 percent and the mean annual absolute humidity is 1.01 X 10^8 Pa.

Atmospheric stability: See Table 1.

Table 1. Atmospheric Stability at the Xudabao Plant Site

Stability	A	B	C	D	E	F
Frequency, percent	0.2	6	13	42	12	27

Precipitation: The mean annual precipitation is 590.9 mm, the maximum daily precipitation is 208.9 mm, the average number of snowfall days is 10, the number of snowfall accumulation days is 22, the freezing period is 114 days, and the frost-free period is 170 days.

C. Fresh Water Sources

There is a water-bearing zone covering an area of 110 square kilometers in the middle and lower reaches of Liugu He about 16 kilometers from the plant site. The aquifer is 20 meters thick. It has a maximum thickness of 35 to 40 meters and is just 1.5 to 3.5 meters deep. The permeability coefficient is 234.4 m/d and the water reserves amount to 210 million cubic meters. In dry years with a frequency p = 99 percent, when the underground water level falls 6.8 meters, the amount of underground water replenishment is 46 million cubic meters. After deducting 25.62 million cubic meters for industrial and agricultural uses, this still leaves 20.37 million cubic meters, which is entirely capable of providing the fresh water utilization requirements of 4 X 1,000 MW nuclear power generation equipment.

D. Seawater Hydrology

1. Tsunamis: Surveys indicate that in a period of about 2,000 years, several rather large "tidal waves" occurred in Bohai Sea. Analysis indicates, however, that most were caused by climatic factors and are non-seismic sea waves. Thus, an epicenter in Bohai Sea would not substantially affect tide levels. Seismic sea waves would not occur in Bohai Sea, whether from the occurrence of an earthquake in it or from transmission of a tsunami from waters outside the sea.

2. Tides: Both the marine areas at the two nuclear power plant sites have non-conventional semi-diurnal tides (that is, two high tides and two low tides daily with obvious tidal differences). The average sea surface is -0.04 meters (the average sea surface of Huang Hai is 0 meters), the design high water level is 1.52 meters, the design low water level is -1.17 meters, the highest astronomical tide is 1.97 meters and the water rise at a frequency p of 0.1 percent is 2.49 meters, so the combined high water level is 4.46 meters.

3. Waves: The primary wave direction is from the south and the secondary wave direction is from the SSW. The strong wave directions are from the south and SSE. When the strong wave direction p is 0.1 percent at a water depth of 10 meters, the H (4 percent) wave height is 5.7 meters. When the strong wave direction p is 1 percent at a water depth of 10 meters, the H (4 percent) wave height is 5.2 meters.

E. Population Distribution

Population data are based on results of the third national population census conducted on 1 July 1982. The average population density for a radius of 50 kilometers is 116 people/square kilometer (the national average population density is 107 people/square kilometer). The population within a range of 10 kilometers accounts for 5.96 percent of the total population within a range of 50 kilometers. Assuming a non-residential area radius of 0.7 kilometer (international GB6249-86 regulations specify a non-residential area larger than 0.5 kilometer), no population resettlement would be required. For a non-residential area radius of 1 kilometer, 167 households with 702 people would have to be resettled. Evaluated according to population grade factors, the 5-kilometer range is a second-grade plant site and all the other items are first-grade plant sites. Table 2 shows the non-residential area radius in some countries.

Table 2. Non-Residential Area Radius in Some Countries

Country	Soviet Union	Italy	United States	India	Czechoslovakia	Canada	England
Radius, kilometers	3	0.8-1.0	0.65	1.6	0.5	1	0.45

V. Environmental Impact

A. Effects of the Surrounding Environment on the Plant Sites

There are no industrial or mining enterprises within 10 kilometers of the plant sites, nor is there any large-scale industrial construction. Preliminary calculations indicate that the risk from small airports outside an area of 10 kilometers to the nuclear power plant has a total probability of 10^{-7}.

B. Effects of the Nuclear Power Plant on the Surrounding Environment

During the preliminary environmental assessment, thermonuclear power plant source items issued by France were used as a reference. Under normal operating conditions, the effects of nuclear power plant radiation on the surrounding environment are very small. At the Xudabao plant site, the maximum individual effective dose would be 0.861 mrem/a and the collective effective

dose equivalent would be 4.50 person x rem/a. The annual dose equivalent created by the natural baseline is about 200 mrem. Under normal operating conditions, the dose equivalent would only be about 5 percent the natural radiation baseline dose. In the biggest imaginable accident, the individual dose equivalent at the boundary of the non-residential area (1 kilometer) from 0 to 8 hours would be full-body 1.214 rem and thyroid 17.46 rem. From 0 to 720 hours, the collective dose equivalent would be full-body 1,671 persons x rem and thyroid 330,000 X persons/rem, all lower than limits in relevant standards. These preliminary calculations were made assuming two 900 MW nuclear power generators and used computation models in management guidance principles NRC 1.111 and 1.109 formulated by the United States' Nuclear Regulatory Commission. The containment vessel leakage rate was 0.1 percent/d within 24 hours after an accident and 0.05 percent/d within 24 to 720 hours. More precise calculations will have to wait until a determination is made concerning the imported generators.

VI. Communications and Transport

The plant site is 107 kilometers from Qinhuang Island and 841 kilometers from Dalian Harbor. There are three transportation programs from the harbor to the plant site.

1. Sea transport: Loading onto a freighter from Dalian Harbor or Qinhuang Island Harbor for shipment through the East China Sea to a pier built for the plant site. The plant site is 250 kilometers from Dalian Harbor and 133 kilometers from Qinhuang Island.

2. Railway: Loading onto a special freight train at Qinhuang Island Harbor and along the Shenyang-Beijing Line to Dongxinzhuang railway station and then from Dongxinzhuang station to the plant site on a 9-kilometer-long special railroad which would have to be constructed.

3. Highway: Through Qinhuang Island Harbor and loaded onto a large flatbed truck and hauled for 98 kilometers on the Shenyang-Shandong highway to Dongxinzhuang. A 9-kilometer-long section of highway would have to be rebuilt and 1.5 kilometers added from Dongxinzhuang to the plant site.

Technical and economic analysis suggests that the highway transport program is the best because highway transport would only require reinforcement of bridges and culverts along the route. The total cost of transformation and shipping would be 12.24 million yuan, whereas the total construction and transport cost of maritime transport from Qinhuang Island to the plant site would be 17 million yuan.

VII. Conclusion

Comprehensive analysis shows that the Xudabao plant site for Liaoning Nuclear Power Plant is a relatively ideal nuclear power plant site. It has good regional stability, low basic earthquake intensity, engineering geology which conforms to requirements, abundant water sources, and a low population density. It would require only a small amount of earthworks, has convenient communications and transport, and the site is broad and flat, making it a rather suitable nuclear power plant site which meets the demands of regulations.

Tibet Building 20 KW Solar Power Facility

90P60011 Shanghai JIEFANG RIBAO in Chinese 10 May 90 p 3

[Summary] The largest solar power facility in Tibet in being built in Gaize Xian, 4,700 meters above sea level. The 20-kilowatt solar power facility will guarantee an electrical supply for broadcasting and television and for improving daily life.

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